

CHAPTER 12

MAINTENANCE

As a Gunner's Mate, maintenance is at the heart of your profession. For you, the art of gunnery comes down to your ability to get the "rounds out" on command safely. The reliability of your gun is directly related to your skill as a maintenance person. This chapter will cover a wide variety of maintenance items. We will begin by discussing the essentials of preventive and corrective maintenance. Following this, we will discuss lubrication, corrosion control, barrel maintenance, and tools. We will then discuss the content and use of equipment maintenance manuals. We will also provide some practical instructions for performing common maintenance procedures, such as replacing hydraulic seals and making mechanical adjustments. Finally, we will discuss some safety precautions that apply to maintenance.

The information in this chapter assumes you have a functional knowledge of the Maintenance and Material Management (3-M) Systems. You may find it useful to review the requirements of the 3-M Systems before beginning this chapter.

PREVENTIVE AND CORRECTIVE MAINTENANCE

LEARNING OBJECTIVES: Discuss the difference between the maintenance completed by the ship's force, tender repairs, and repairs handled by the shipyards. Briefly describe the Phased Maintenance Program (PMP) and its primary elements.

The term *maintenance* includes many different types of tasks. However, all maintenance is classified as either preventive or corrective. In this section we will discuss the elements and implications of preventive and corrective maintenance. The intent of this section is to provide you with a sense of the importance of your role in keeping your gun operating smoothly and safely.

PREVENTIVE MAINTENANCE

Of the two main classes of maintenance work, the most important, which accounts for most of the maintenance work you do, is preventive maintenance. Preventive maintenance consists mainly of the regular lubrication, inspection, and cleaning of your

equipment. The purpose of preventive maintenance is to prevent malfunctions before they appear and discover existing malfunctions before they become critical. Preventive maintenance is based on the well-known principle that an ounce of prevention—in the form of adequate routine maintenance—is worth a pound of cure—in the form of emergency repair, replacement, and overhaul.

Preventive maintenance is neither dramatic nor exciting. While the need for routine lubrication is obvious, you may envision your leading petty officer (LPO) as being a little obsessive when it comes to gun mount cleanliness and inspection. You may think time spent cleaning and inspecting components that have always been in good shape to be a waste. However, you will realize this time has been well spent when you consider the impact that an undiscovered hydraulic leak or a missing retainer clip could have in the midst of firing the gun. These situations represent major casualties just waiting to happen with serious and sometimes fatal consequences. By taking a little time and trouble to do routine preventive maintenance now, you can save yourself a lot of work later by heading off breakdowns and time-consuming emergency repair jobs.

The Navy uses maintenance requirement cards (MRCs) in the planned maintenance system (PMS) to make sure routine maintenance jobs are done at the required regular intervals—daily, weekly, monthly, and so on,—and no steps are forgotten.

MRCs are obtained from the Gunner's Mate under whom you work. They provide a step-by-step guide for performing a specific maintenance action. MRCs prescribe the minimum required preventive maintenance for a given gun mount. MRCs cover all lubrication, some inspections, and some cleaning. Anyone with a little training can perform maintenance from an MRC. However, an MRC will not tell you to inspect mechanical linkages for cracks or missing retainer clips while you lubricate each of its pivot points. It will not instruct you to determine the cause of a fresh puddle of hydraulic fluid on the deck under a piece of gun loading machinery and initiate steps to have it repaired. As you become more knowledgeable in gun mount maintenance, you will develop an

appreciation for the importance of these unstated commonsense preventive maintenance practices.

As stated earlier, MRCs cover all minimum lubrication requirements. However, you or your LPO may determine that it is necessary to lubricate certain mechanisms more frequently during very heavy operational conditions. This is acceptable and shows that you possess a good understanding of the actual purpose of maintenance—to keep the system operational!

Inspections required by MRCs normally consist of checks that verify fluid levels in hydraulic and gearbox reservoirs and mechanical adjustments and clearances. The term *inspection* may also be applied to MRC-directed equipment operational checks, electrical continuity checks, and gun order checks.

A good example of cleaning maintenance required by an MRC is the removal of lubricants from the gun barrel before firing and the removal of residue from the barrel after firing. Other cleaning maintenance covered by MRCs includes the cleaning of electrical contacts and the removal of excess grease from around grease fittings after they have been lubricated. The general cleanliness of your equipment is also an important factor. Dirt and dried hydraulic fluid on machinery make it less likely that you will notice a fresh leak or damaged component. It is also much more pleasant to work on clean equipment.

In addition to MRC-guided preventive maintenance, you have the system maintenance manuals. These manuals contain detailed descriptions of the operation and care of the gun systems. You should be intimately familiar with these manuals. They include all the clearances and tolerances for the mechanical systems of the guns as well as detailed procedures for component replacement. MRCs do not require the verification of the majority of these adjustments and clearances. Over the years, mechanical equipment wears, the hull of the ship twists, and mechanical adjustments slip. For this reason it is a good practice to review system maintenance manuals to identify these adjustments and clearances. Routinely including the verification of some of these adjustments in your preventive maintenance schedule will serve to extend your knowledge of the operation of the system while helping to ensure its reliability. These adjustments also make good topics for professional training. Mechanical adjustments are covered in more detail later in this chapter. Further discussion on maintenance manuals is also covered later in this chapter.

NOTE

Be sure to consult with your supervisor before attempting to correct any equipment misalignments.

Let's tie all these ideas together as we close out this section on preventive maintenance. As a maintenance person you have three good tools available to help you keep your equipment operating at peak performance—MRCs, system maintenance manuals, and common sense. MRCs form the foundation of preventive maintenance by providing minimum maintenance standards. System maintenance manuals provide additional in-depth system operation and maintenance information. Effective preventive maintenance requires a high level of technical knowledge mixed with some good old-fashioned common sense. You can do the minimum required maintenance and be within the letter of the law, but still have the least reliable gun on the waterfront, and be known as a poor maintenance person. You may believe that you are a maintenance person because you can complete the MRCs assigned to you. However, if the extent of your maintenance expertise encompasses only the requirements of your systems MRCs, then you are really only a maintenance person's helper. A maintenance person has, or is continually working on, an in-depth understanding of the system. When you invest that little extra time on the gun while performing routine lubrication, you can take a good look at the gun to make sure all is in order. You will see in the next section how preventive maintenance is the foundation of corrective maintenance.

CORRECTIVE MAINTENANCE

Corrective maintenance involves the repair or replacement of gun components that have been identified as worn, defective, or broken. In the course of routine preventive maintenance, you will discover components that require repair. This is the ideal situation—find the casualty and repair it before it affects the operation of your gun in a firing situation. Occasionally, however, in spite of the best preventive maintenance, equipment will unexpectedly malfunction or break down altogether during an exercise. You must acknowledge this eventuality and be ready to deal with it when it occurs. Remember, a comprehensive preventive maintenance program will keep these occurrences to a minimum.

The more you know about how your equipment works, the better you will be at troubleshooting and repair. Experience is a great teacher, but you cannot wait until your gun breaks down in battle to find out how to repair it. This is where the knowledge and habits you developed in performing preventive maintenance really pay off. The maintenance person who has studied and understands the details of how the system works will have a head start in detecting the cause of any malfunction. This is especially true of electronic control circuit casualties. Casualty diagnosis is the heart of the corrective maintenance problem. Once the casualty has been accurately diagnosed, component replacement is normally a simple task. If you routinely experience casualties in your system during firing exercises, especially mechanical and hydraulic casualties, you need to take a serious look at your preventive maintenance habits. Constant test operation and inspection of your gun system is the only sure way to detect problems before they can get serious enough to put you out of action.

PLANNED MAINTENANCE SCHEDULES

Until now, your experience in PMS management has probably been limited to duties as a work center supervisor. As a result, you were closely involved in the day-to-day upkeep of the cycle, the quarterly, and the weekly PMS schedules of your particular work center. As an LPO, you may frequently find yourself assigned as a group supervisor. This means you will be supervising other work centers within your division or department. Consequently, you will be spending more time in the upkeep of PMS schedules. As you can see, knowing how to make up the cycle, the quarterly, and the weekly schedule is an important aspect of a CPO's job.

Although the department head is responsible for the preparation of the cycle schedule, this duty is often delegated to the chief. Special care should be taken in the preparation of the cycle schedule because it will directly affect the long-range scheduling of PMS due to operational schedules, overhaul cycles, and availability periods.

The cycle schedule is used as the basis for the preparation of the quarterly schedule. Concurrently, the quarterly schedule is used as the basis for preparing the weekly schedule.

Because you should already be thoroughly familiar with the preparation of PMS schedules, it will not be discussed at any great length in this text. These

procedures are described in detail in chapter 5 of OPNAVINST 4790.4.

Maintenance Skills

In performing any type of maintenance, a Gunner's Mate requires specific information relating to the particular equipment to be maintained and repaired. You must also possess the required skills and knowledge that apply to the maintenance of a myriad of equipment. The information needed can be found in the particular OP of the system, but skill and knowledge take many hours of dedicated training to develop and fine tune.

We can assume that you have developed those general skills by following the procedures as set forth in your personnel advancement requirements (PARs). As the LPO, you must be prepared to teach those skills to your subordinates. Your trainees will not be too impressed if you do not know how to take an ohmmeter reading or check the clearance of a microswitch. You must learn more about the overall and continuing plan of maintenance and the responsibilities of administration, as well as the technical duties in maintenance.

Maintenance Planning

A study of the occupational standards shows that the GM1 must be able to overhaul, repair, test, adjust, and record all authorized maintenance performed. Note that nearly all the knowledge factors are required at the GM3 and GM2 level, with exception of the principles of receiver-regulators, functions of fire control, and supply procedures. You are expected to have knowledge of the basic geometric layout for drawings and sketches, to be able to prepare freehand sketches, and to read and interpret diagrams and service instructions.

The success of any planned maintenance program depends upon the cooperation you receive at the working level. Your maintenance personnel need to understand how their day-to-day work of lubrication, cleaning, and similar routine upkeep helps prevent costly and time-consuming breakdowns and the subsequent hard repair work.

The responsibility of the leading GM in administering the PMS and the MDS is described generically for PO1 in OPNAVINST 4790 (latest revision). Planning the daily maintenance work is your responsibility.

System Preventive Maintenance

Preventive maintenance components are built into some ordnance systems to help detect faults within the systems. One of these components is a ground detection indicator.

The ground detection indicator is a continuous monitoring system designed to detect a system ground. Since most control circuits in ordnance systems are powered by ungrounded 115-volt, 60 hertz, single-phase current, the first ground is not very important from an operational point of view. However, if the first ground is not discovered and a second develops, the result could be an illogical and destructive sequence of system operation. The reason for this is that two grounds act as electrical conductor between the grounded components. When the ground detector indicates (by light or buzzer) that some of the control circuitry is grounded, you should determine the location and cause of the ground. The elimination of most grounds and potential grounds is good maintenance and housekeeping.

MAINTENANCE BY SHIP'S FORCE, TENDER, AND NAVY YARD

Most of the maintenance work on armament aboard ship is done by the strikers and Gunner's Mates themselves as part of the ship's routine. This is called ship's force maintenance.

The ship's force, however, does not have the facilities or the skills to perform certain less frequent, but equally necessary, maintenance operations. Examples of this type of operation are repair of gunsight or boresight telescopes and calibration of pressure gauges. Work of this nature is done aboard repair ships and tenders that have the equipment and skilled personnel required for this type of repair work.

Lastly, there are some jobs, like major overhaul of hydraulic systems or repair or replacement of roller paths, that are customarily completed in shipyards. Such work may be completed by yard workers, by the ship's force, or by both. Maintenance work completed in shipyards is termed *navy yard maintenance*.

Routine overhauls are scheduled far ahead of time at a specified navy yard for each ship. To get the most out of the overhaul work, you must keep records of mishaps, signs of defects, or poor operation of gunnery equipment so that each of the items can be taken care of during the overhaul. You must also keep records of all repair work done by the ship's force. Keeping the

records is part of your job; the weapons officer must have this information to plan the overhaul work. Pending maintenance and equipment history records are maintained as part of the maintenance data system (MDS) that is a part of the 3-M Systems. The documentation of equipment malfunctions is briefly described in the "Common Maintenance Procedures" section of this chapter.

Work by tenders and repair ships are also scheduled, so it must be planned for ahead of time. Authorized alterations (ORDALTs) are also made aboard these ships when possible, although some may be accomplished by ship's force but supervised and verified by the appropriate Navy Sea Support Center, Atlantic or Pacific (NAVSEACENLANT/PAC). ORDALTs requiring special team efforts will be accomplished under the direction of NAVSEACEN personnel and supported, as required, by the in-service engineering agent and/or contractor representatives. ORDALTs usually state by whom the work is to be done. Changes of a minor nature are authorized by NAVSEASYSCOM instructions.

The upkeep period is time assigned to a ship while moored or anchored or when the ship's force and other forces afloat can work to perform upkeep duties without interruptions.

Special assistance in maintenance, especially for new equipment, may be obtained from contract service engineers who are specifically trained for specific equipment, or from mobile ordnance technical units (MOTUs) which consist of military personnel who have been trained to handle certain equipment and can be assigned to instruct others in its use and care.

OVERHAUL WORK PACKAGES

All U.S. Navy ships are assigned regular overhaul availability cycles for the purpose of maintenance and updating/improvement of the ship and its installed equipment. The two types of availability are the Regular Overhaul (ROH), and the Phased Maintenance Program (PMP). As a leading GM, you will be closely involved with the planning and implementation of these programs. In addition, you will also have to supervise the maintenance of your assigned equipment through the use of Inactive Equipment Maintenance (IEM).

Regular Overhaul (ROH)

One of the most important considerations affecting the performance of ship's overhaul is the determination of what work is actually to be performed during the

ROH. This phase of the planning process is developed into the Ship Alteration and Repair Package (SARP) or the Integrated Work Package (IWP) as applicable. Because the SARP/IWP is both a planning and working package for ROH, it will be addressed at this time.

For most ships, a SARP is the document that defines and authorizes work to be done during the overhaul, assigns the level of accomplishing activity for each work item, and indicates cost estimates for each shipyard job. The IWP performs the same functions for small ships (ARS/ATF/MSO) when the OPNAV 4790.2K maintenance forms are arranged in order by ship system. The purposes of the SARP (or IWP) are as follows:

1. Integrates related customer work requirements
2. Resolves redundant and conflicting work requirements
3. Identifies work on a ship system basis
4. Serves as the single source document for all customer authorized work

The SARP/IWP is maintained as a continuing document that contains the information necessary for the following:

1. Estimating the overhaul cost and duration
2. Early decision making by higher levels of command concerning budgeting, funding, operating schedules, and overhaul duration
3. Commencement of additional advance planning, design work, and material procurement by those activities responsible for supporting and conducting the overhaul

Key inputs for developing the SARP/IWP are as follows:

1. The Current Ship's Maintenance Project (CSMP) as submitted by the type commander to the cognizant Planning and Engineering for Repairs and Alterations (PERA) approximately 12 months in advance of the ROH start date
2. Results of the Pre-Overhaul Tests and Inspection (POT&I)
3. Type commander Title "D" SHIPALT Authorization Letter
4. NAVSEASYS COM Title "K" SHIPALT Advance Planning/Authorization Letter

For ships using the SARP overhaul package, the following action will be taken (approximately 90 days

before the overhaul commencement or when the SARP screening action has been provided to the ship):

1. Work discovered during POT&I and designated for IMA accomplishment will be documented on an OPNAV Form 4790.2K and coded for availability.
2. Work previously documented into the CSMP file, but which was originally coded for other than IMA accomplishment, and for which subsequent screening action changed the accomplishing activity to IMA, will require submission of a correction document (OPNAV Form 4790.2K) to change the type of availability code.

The above work items, along with those already coded for IMA accomplishment in the ship's CSMP file (plus any desired master job catalog items), will form the IMA work package for preoverhaul and concurrent IMAVs.

The time between regular overhauls varies from 2 years to 5 years. The interval is the maximum period consistent with keeping the ship in fighting trim.

An analysis of the problem of building, overhauling, or converting ships reveals that the following factors play essential roles:

1. The ship must be available for the uninterrupted accomplishment of yard work.
2. The contemplated work must be decided upon, arranged in order of priority of accomplishment, and actually authorized to be performed.
3. Sufficient funds must be available to cover the cost of the work.
4. Material must be available.
5. Personnel must be available to do the work.

Advance Planning

The advance planning stage of the regular overhaul begins approximately 18 months before the scheduled beginning of the overhaul. During this stage, the plans progress from a very rough to a refined and definite schedule. In the broad sense, advance planning provides a solid foundation for the accomplishment of work on naval ships in all shipyards. Availabilities of ships are approved by CNO on a fiscal-year basis. Before they are approved, schedules are commented on by forces afloat and NAVSEASYS COM.

The main factors considered in formulating the overhaul schedule are as follows:

- The home port of the ship
- The intervals between the previous overhaul availabilities of the ship and the proposed overhaul
- The placing of the ship in the home shipyard or shipyards capable of performing any required special type of work
- The provision of a level of work in all shipyards to avoid laying off personnel intermittently
- The probable availability of critical material on important jobs
- Any special factors that may arise

The final approved schedule represents the best compromise possible. It is used as a basis for planning by the material commands, the shipyards, and the forces afloat.

It is quite possible, in view of the remote, long-range nature of the schedule, that changes and adjustments may be required from time to time. As the need arises, proposed changes are evaluated and approved/ disapproved by CNO. Changes in start or completion dates may be made by the type commander with the concurrence of the shipyard commander or the superintendent/supervisor of shipbuilding (SUPSHIP) when the change is 3 weeks or less from the assigned date.

Advance planning on the part of the ship's personnel is necessary for a successful overhaul. The commanding officer must ensure that adequate plans and preparations are made for the accomplishment of the following activities:

1. Work of ship's force
2. Training of the ship's personnel during the overhaul
3. Security of the ship's spaces, including protection against fire, flooding, theft, and sabotage

All work within the capacity of the ship's force should be accomplished by the ship's personnel. A schedule of the work of the ship's force should include the names of the persons responsible for performing the work, the estimated date of completion, the estimated number of work hours required for completion of the work, and a list of the necessary materials or tools required from the shipyard to perform the work.

Plans for training during the overhaul period should outline the objective to be accomplished by the

end of the period. Local training facilities and fleet schools should be used to the maximum degree consistent with obtaining a good overhaul.

While the ship is undergoing overhaul, special precautions against fire, flooding, theft, and sabotage must be taken. The shipyard is prepared to help with matters of security, but the responsibility for establishing security measures remains with the ship's personnel. The overhaul plan should include the necessary organization for these precautions.

PRECAUTIONS AGAINST FIRE.—The greatest continuous hazard to ships undergoing overhaul is fire. Disruption of fire-fighting facilities and burning or welding work in progress are the most dangerous conditions contributing to fire hazards. The ship's force is responsible for providing properly trained fire watches for each burning or welding job in progress aboard ship. All watch personnel should be instructed in the location of the shipyard fire alarm boxes nearest to (or on) the ship and the current shipyard directives concerning fires and fire fighting.

PRECAUTIONS AGAINST FLOODING.—The possibility of engineering spaces flooding through sea connections or through leaks in piping systems must not be overlooked. The security plan should require frequent inspections of all unattended spaces in which this possibility exists.

PRECAUTIONS AGAINST THEFT AND SABOTAGE.—Responsibility for the security of the ship against acts of theft or sabotage rests largely with the security watches and the inspectors of shipyard work. Security measures should be enforced tactfully, so shipboard personnel will not be offended. To reduce the possibility of theft, you should place all tools, valuables, and clothing in locked stowage. Stowage spaces within the shipyard may be available to the ship's force for this purpose. Acts of sabotage can best be prevented by the vigilance of watch and duty personnel. Periodic patrols conducted at irregular intervals through ship's spaces and proper identification of all personnel boarding the ship are basic requirements for security.

Ship's Force Overhaul Management System (SFOMS)

Effective management of resources is a continuing challenge at every level of command in the Navy. Spiraling costs, the growing complexity of mechanical and electronic components, and the limitations of funds, skills, and time available for proper maintenance

of naval ships demand full use of the best management techniques. The SFOMS provides management techniques for the control of ship's force work during an overhaul. The SFOMS also provides the necessary elements for a smooth transition from an operating environment to an industrial maintenance environment.

The commanding officer is directly responsible for the effective accomplishment of all ship's force jobs, and for the management of both human and money resources during the overhaul (availability) so that upon completion of the work, there is a dependable, trained, and responsible crew. At the same time, the ship's company must have the leave and recreation they need. SFOMS provides the tools to help in attaining these goals. The system provides for a staff of shipboard personnel to schedule, manage, and control work to be accomplished by the ship's force by

- identifying work that must be done;
- finding out what work force, materials, and facilities are required and available; and
- developing cost estimates and schedules.

In this way SFOMS helps achieve an effective overhaul; that is, completion of the work at the least cost and in the minimum time without sacrificing quality. However, SFOMS is no longer a required management program; its use is at the discretion of the commanding officer. Further information and guidelines for the use of SFOMS are located in the NAVSHIPINST 5450.180.

Phased Maintenance Program (PMP)

The PMP is a maintenance strategy in which depot level maintenance is performed in a series of short, frequent, phased maintenance availabilities (PMAs) instead of regular overhauls. To the maximum extent practicable, repairs are authorized based on the actual material condition of the ship and its equipment. In addition to innovative material support procedures, PMP contracts enable depot level maintenance to be performed by a single contractor throughout a complete operating cycle. The goals of the PMP are maximum ship availability, improved operational readiness, and upgraded material condition.

Primary Elements of PMP

The primary elements of the phased maintenance program consists of the operating and maintenance schedules, the port engineer, the material support

initiatives (prepositioned equipment), the class maintenance plan (CMP), and contracting for PMAs.

OPERATING AND MAINTENANCE SCHEDULES.—Operating and maintenance schedules incorporate PMAs of 2 to 4 months duration at intervals of approximately 15 to 18 months. Minor variations allow for operating cycle differences between classes. One PMA in the cycle is extended by 1 month to include dry docking. PMAs include both repairs and modernization.

PORT ENGINEERS.—Port engineers manage the planning for, monitor the execution of, and evaluate maintenance work on the small number of ships each port is assigned. They carry out these functions through personal observation and direct contact with ship's force, group staffs, NAVSEADDET PERA, SUPSHIPS, TYCOM SUPPORT GROUPS, and other planning agencies. Port engineers are primarily concerned with depot level repairs and secondarily with IMAVs. Port engineers are directly responsible to TYCOM staff maintenance officers for planning, for work definition, and for screening recommendations. This includes conducting work definition conferences (WDCs). Through a memorandum of understanding (MOU) between TYCOM and the individual SUPSHIPS, the relationship between SUPSHIP and the port engineer is established, particularly regarding the joint authorization of any growth work by the port engineer and SUPSHIP. (New work may only be authorized by SUPSHIP after TYCOM port engineer concurrence.) Port engineers, however, do not authorize ship alterations.

MATERIAL SUPPORT INITIATIVES.—Material support initiatives for PMP are the use of prepositioned equipment for change-out instead of repair and contingency spares to prevent delays of scheduled PMA completions because of the lack of repair parts. The prepositioned equipment is limited to a small number of major items, and the contingency spares are kept at or near the industrial activity.

Readily available parts in the Navy or Defense Logistics Agency (DLA) supply systems are excluded from contingency spares.

CLASS MAINTENANCE PLAN (CMP).—The class maintenance plan defines anticipated organizational, intermediate, and depot level maintenance requirements for systems and equipments throughout the operating cycle. Except for "legislated" requirements, a CMP task does not imply mandatory accomplishment. The judgment of the port engineer,

actual equipment condition, priorities, and risk assessment are part of the repair decision.

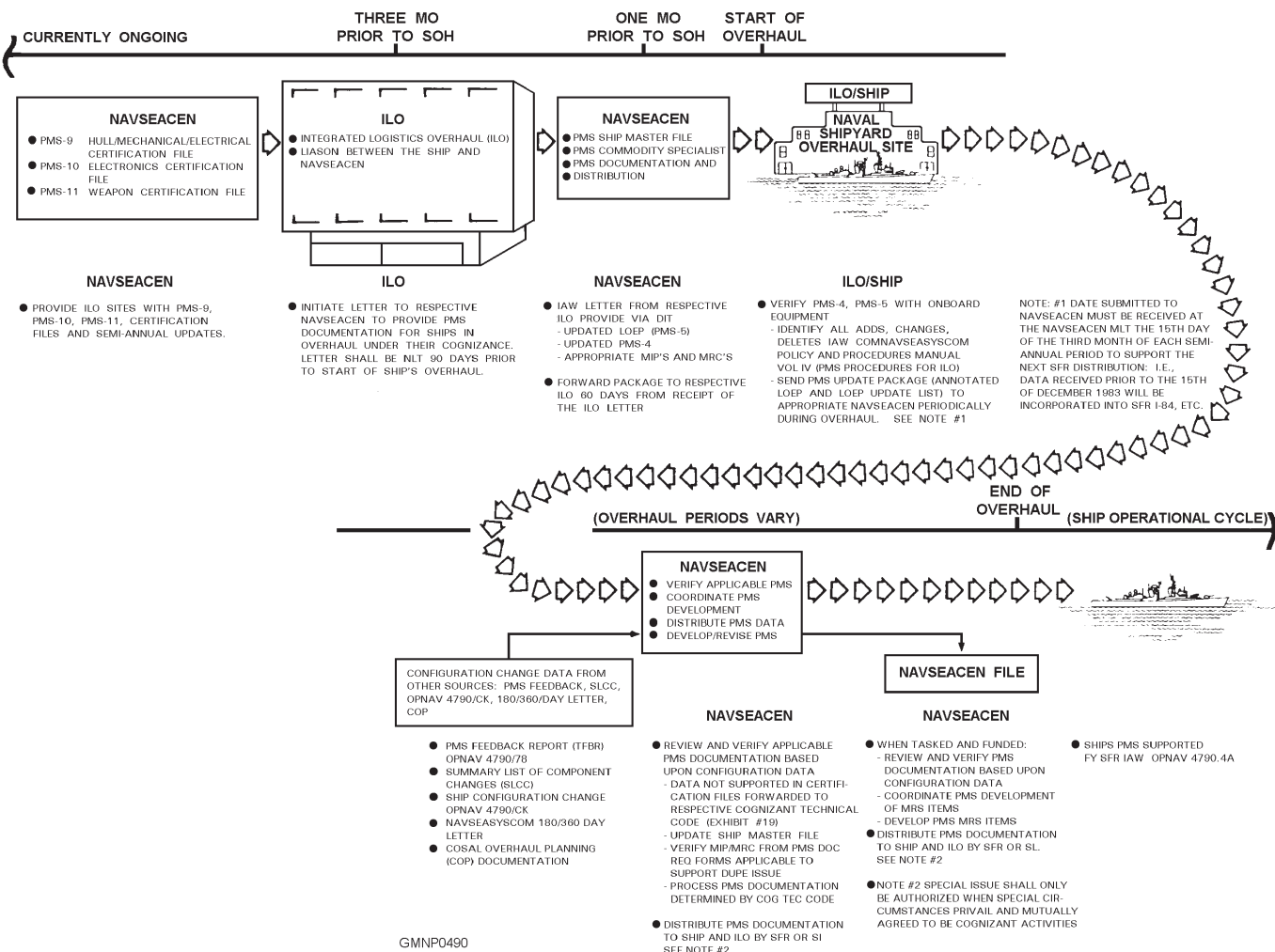
CONTRACTING FOR PMAs.—Contracting for PMAs is generally accomplished by the award of an incentive type, multiship/multiyear option contract with a competent contractor, usually in the ship's home port. Although in particular circumstances other types of contracts may be used, the main objectives of this type of contract are as follows:

1. To avoid the requirement to specify an inflexible work list before the availability is negotiated
2. To allow incentive payments for cost control, high quality, and schedule adherence
3. To allow the crew to live in home port during shipyard periods
4. To obtain "learning curve" payoffs in the form of improved efficiency and familiarity for both

shipyard and ship's force, resulting in long-term savings in dollars and workdays

Overhaul Maintenance Requirements

During an overhaul period, work that pertains to the repairing, docking, and altering of the ship is done by the shipyard work force. At the same time, however, shipboard equipment is still maintained by ship's force personnel. Although most shipboard equipment is shut down and not in use during an ROH, it still must be kept in the best possible condition of readiness. This is accomplished through the use of Inactive Equipment Maintenance (IEM). At the same time, the shipboard PMS package is going through a constant updating process. The flow of PMS documentation involved during an ROH period is shown in figure 12-1. The Integrated Logistics Overhaul (ILO) concept was developed because of logistic support problems



existing in the Supply Operations Assistance Program (SOAP). The ILO program provides more comprehensive PMS documentation and supply support for shipboard equipment, including equipment that may not be affected during an overhaul. NAVSEA is responsible for the development and implementation of the use of the ILO program. Information about ILO-governed PMS procedures is contained in *COMNAVSEASYS- COM Policy and Procedures Manual*, Volume 4, (*PMS Policy and Procedures for ILO*), SL105-AA-PRO-040/ILO.

As you can see, the PMS documentation process for an overhaul period starts long before the overhaul actually begins and proceeds through the ROH and afterwards. Table 12-1 lists the Pre-ROH, during ROH, and Post-ROH actions and responsibilities for a ship to maintain its 3-M program while involved in an overhaul.

During an ROH, much of your equipment is naturally going to be removed, partially dismantled, or shut down. However, some equipment must be maintained while inoperative through the use of

Table 12-1.—ROH-Related 3-M Actions

STAGE IN SHIP'S LIFE CYCLE	3-M ACTION TAKEN	WHEN ACCOMPLISHED	WHO ACCOMPLISHES
PRE-REPAIR AND OVERHAUL:	Update CSMP	According to TYCOM ROH Milestones	Ship
	Generate Automated Work Request Package	According to TYCOM/IUC ROH Milestones	ADP Facility or Ship
	Implement IEM	Equipment is Taken Off the Line for Extended Periods	Shipyard or Ship
DURING REPAIR AND OVERHAUL:	Compare and Verify LOEP Provided by NAVSEACEN Against Ship's Configuration Baseline Determined by ILO Team	Throughout Overhaul IAW SL 105-AA-PRO-0a40/ILO	ILO
	Implement IEM	When Equipment is Placed in Extended Inoperative Status	Ship
	Phase-Out IEM Procedures and Commence Normal Operational PMS	Immediately Prior to Each System's Light-Off	Ship
	Update PMS Package	Upon Receipt of SFR Package, Prior to Completion of ROH IAW SL 105-AA-PRO-040/ILO	Ship/ILO
	Update CSMP	Continuing	Ship
	Configuration Changes Installed by Ship Reported to ILO	Throughout Overhauls and Availabilities with ILO or LOG REV	Ship
POST REPAIR AND OVERHAUL:	Update CSMP	Immediately Upon Completion of ROH	Ship
	3-M Assist Visit	As Requested by Unit	TYCOM 3-M Team/NAVMASSO's

Inactive Equipment Maintenance. Essentially, IEM provides modified maintenance for equipment that is to be inoperative for extended periods of time. Figure 12-2 shows how a quarterly schedule is modified to include IEM requirements. Shown are two quarterly cycles with IEM beginning in the 23rd quarter and ending 4 months later during the 24th quarter. Basically the schedule remains the same, but the changes (as denoted by the circled numbers with arrows) are explained as follows:

1. When making out the new schedule that includes a portion of the ROH, draw red-colored vertical lines on the schedules designating the start and end of the overhaul. Indicate the IEM status of the equipment by entering a II or III. IEM status categories are identified in chapter 6 of OPNAVINST 4790.4.
2. Considerations, such as whether the ship is in dry dock under own-ship's power or air conditioning is available, should be noted as aids in scheduling maintenance requirements in the event that specific services or conditions are necessary to complete the check.
3. Operational PMS should be scheduled as normal up to the beginning of the ROH period.
4. Indicate "YD" with an arrow-tipped line on the MIP line for the equipment that yard personnel or contractors are responsible for.
5. Schedule operational PMS for equipment that will remain operational during the ROH.
6. From the IEM section of the MIP, schedule in green all lay-up and periodic maintenance requirements. Note the scheduling of periodic maintenance of a different periodicity than that specified on the MRC. In this case, for example, the W-2 will only be accomplished monthly as designated by (M) written on the schedule beside the W-2 requirement.
7. Schedule start-up maintenance, and if necessary, operational tests toward the end of the ROH period.

When making the transition into the operational portion of the schedule, do not reschedule requirements that have been accomplished by IEM actions.

Weekly PMS schedules are modified in the same manner as quarterly schedules by drawing a line through the preprinted operational requirements and substituting the IEM requirements.

Guidelines for the proper use and documentation of Inactive Equipment Maintenance are located in chapter 6 of OPNAVINST 4790.4.

LUBRICANTS AND CORROSION CONTROL

LEARNING OBJECTIVES: Discuss the characteristic properties and functions of lubricants. Identify lubrication symbols used on charts and drawings. Explain why corrosion control is an important part of any maintenance program.

If you grew up in a large city, perhaps the only connection you had with lubrication was taking the family car to the garage or the gas station for greasing and an oil change. But, if you grew up on a farm or had a car that you had to keep in running condition yourself, you are well aware of the need for regular lubrication of all moving parts. If your car had a burned out bearing, you learned a lesson that you are likely to remember. Since you have been in the Navy, you have heard a lot about the importance of lubrication. We place additional emphasis on the subject in this section as we describe the different lubricants and lubrication tools that you will encounter. We will also discuss some of the fundamentals and practices involved in corrosion control.

QUALITIES OF LUBRICANTS

Lubricants are of two general classes—oils and greases. Oils are fluids; greases are semisolids at ordinary temperatures. Both have several qualities that determine their suitability for a particular lubrication job. One of the most important is viscosity.

Viscosity is the measure of the internal resistance of a fluid that tends to prevent it from flowing. It varies with the temperature as well as with the nature of the substance. Petroleum jelly can hardly be said to flow at room temperature, but it can be melted to a rather thin liquid. On the other hand, many kinds of oils flow readily at ordinary temperatures but become much thicker when they are cold. A fluid that flows easily has a low viscosity, while a fluid that flows slowly has a high viscosity.

Viscosity is expressed in terms of S.S.U. units. (S.S.U. means Seconds Saybolt Universal and represents the number of seconds it takes a given quantity of the lubricant at a specified temperature to pass through the Saybolt Universal Viscosimeter or Viscometer.) The higher the S.S.U. number of a lubricant at a given temperature, the more viscous the liquid. The Navy uses the S.S.U. measurement, rather than the S.A.E. (Society of Automotive Engineers), grades to designate lubricants.

The viscosity index (VI) is an indication of the variation of viscosity of the lubricant with variation in temperature. The higher the index, the less the viscosity varies with the temperature. Thus a high index is a desirable quality. You want a lubricant that will not solidify and gum up in cold weather nor liquefy and leak away in hot weather.

A viscosity index can be improved up to a point by putting chemical additives into the oil. (Additives are put in by the manufacturer. Do not try to brew up your own special oil by adding anything to it.)

The flash point of a lubricant is the temperature at which it gives off flammable vapors. The fire point (always higher than the flash point) is the temperature at which it will catch fire if ignited and continue to burn. The pour point (of an oil) is the lowest temperature at which it will pour or flow.

Oiliness is the characteristic of an oil that prevents scuffing and wear. You might think this depends on viscosity, but a complicated relationship of many factors is involved. Certain substances have been found that increase the oiliness of a lubricant.

Chemical stability is the ability of the lubricant to "take it." Certain oils and greases tend to deteriorate under the influence of high temperatures, exposure to air or water, or introduction of impurities. A lubricant with good chemical stability will resist such deterioration. You can often detect deterioration by change in color, by formation of varnish or gum deposits, by formation of sludge, by change in viscosity (of oil) or consistency (of grease), by hardening (of grease), or by other telltale signs. Change in viscosity can be more accurately measured by a viscometer, but serious change is easy for the expert to detect.

These signs of deterioration mean that the lubricating and corrosion-preventing qualities of the substances are impaired. You will find it useful to know the signs of deterioration in oils and greases well enough to recognize them should they appear.

Lubricants, preservatives, and hydraulic fluids all protect metal against corrosion, at least to a certain extent. Corrosion prevention is, of course, the main function of a preservative. The corrosion-resisting qualities of lubricants and hydraulic fluids can be improved by adding chemicals, called inhibitors. In general, inhibitors are added to the substance by the manufacturer before delivery to the Navy.

Other qualities or properties of lubricants are the dropping point, the penetration, the neutralization

number, the work factor, the viscosity change, and the aniline point. Chemists working with lubrications need to understand the meaning of these terms; we list them only to impress upon you that not just any oil will do.

FUNCTIONS OF LUBRICANTS

Lubricants are used for three purposes—to reduce friction, to prevent wear, and as a protective cover against corrosion. As a protective cover against corrosion, the use is obvious. As a preventive against wear, the use is equally obvious when you consider the matter of friction. Lubricants form a layer or film between the metal surfaces that actually keeps the metals from touching. The moving parts literally ride on the lubricant. In the instance of two metal surfaces sliding across each other where space cannot be provided for ball bearings, the lubricants themselves serve as liquid bearings. In all mechanical devices, lubrication is necessary to counteract friction as much as possible. The presence of only a thin film of lubricant separating metal surfaces keeps machinery running. If the film disappears, you have hotboxes, burned-out and frozen bearings, scored cylinder walls, leaky packings, and a host of other troubles—the least of them being excessive wear. All of these troubles are the result of direct metal-to-metal contact without adequate lubricant.

Specifications

Because proper lubrication is an absolute necessity, selection of high-quality lubricants having the right viscosity and other properties for each job is of vital importance. When you drive your car into the local filling station and tell the attendant, "One quart of 10W30 oil," you are specifying the kind of oil you want.

Most lubricants, hydraulic fluids, cleaners, coolants, and related materials used by the Navy are purchased under federal or military (MIL) specifications. These specifications supersede all specifications formerly issued by the Navy. Table 2-3 in NAVSEA OD 3000, *Lubrication of Ordnance Equipment*, cross-indexes superseded Navy specifications and designations with the current federal or MIL specifications.

The specifications are identified by names, numbers, and letters. Lubricants, preservatives, hydraulic fluids, and many other items are often known and referred to by these specification numbers and symbols alone. An example of an item you have probably

already used is MIL-F-17111—a power transmission fluid.

Oils

Many oils used by the Navy in ordnance equipment are identified by four-digit symbols preceded by the letters MS (military symbols). You need to be able to read and translate these symbols.

The following classes of MS oils are approved for use in naval ordnance:

- Class 1 – Aircraft engine oils
- Class 2 – General-purpose lubricating oils (130°F)
- Class 3 – General-purpose lubricating oils (210°F)
- Class 5 – Mineral cylinder oils

The viscosity for oils of classes 1, 3, and 5 is determined at a temperature of 210°F and for oil of class 2 at 130°F. These classes are straight petroleum-based oils without corrosion inhibitors.

Now, assume the MS on a certain oil is 2135. What does this tell you about this oil?

The first digit tells you that the oil is class 2, a general-purpose lubricating oil. The last three digits indicate the viscosity as 135 at a temperature of 130°F. That is how you read military symbols for oils.

On lubrication charts, note that the number of the lubricant to be used at each place is not repeated, but a "target" symbol is used instead. This avoids confusion with the number used to identify the part to be lubricated, which may be used several times in the chart. The meaning of the target symbol is explained in the notes on the chart, as well as in OD 3000.

Greases

Lubricating greases are a mixture of soaps—commonly, calcium or sodium soap—and lubricating oil. The oil may be a mineral oil (petroleum-based) or a synthetic oil.

The purpose of the soap is to make the oil stay put at the point of application. The soap traps the oil within its mass, but the actual lubrication is done largely by the oil in the grease. You might think of it as an oil-soaked sponge. The heat of friction squeezes the sponge, melting the grease and releasing the oil to perform the lubrication.

Greases are classified according to the kind of soap used in making them. Each kind of soap has specific properties.

Calcium (lime) soap grease will not absorb moisture or emulsify (separate into its original ingredients). Consequently, it is specified for general lubricating purposes where bearings are exposed. However, calcium soap grease has a low-melting point and is not suitable for hot-running bearings.

Sodium-soap grease emulsifies in the presence of moisture but has a higher melting point. It should be protected from moisture. It is used for ball and roller bearings.

Other kinds of soap bases used in greases are aluminum soap and lithium soap, with others added to the list through experimentation and test at laboratories.

Graphite grease, as the name implies, contains graphite. The graphite acts as a mild abrasive to smooth roughened wearing surfaces, as a filler to smooth over any pits in the surfaces, and as a friction reducer. However, because of its abrasive action, graphite grease should not be used in bearings that are in first-class condition, except under high temperatures when ordinary greases would be destroyed. Technically, since graphite grease contains no soap, it is classed as a lubricant oil, but it looks and is applied like other greases.

Gear lubricants are a mixture of high-viscosity oils and just enough sodium soap to cause jellying. Gear lubricants are suitable for high gear tooth pressure and moderate speeds where the design of the case is such that ordinary oil cannot be retained.

As with oils, the viscosity of greases varies with temperature. If temperature changes make it necessary to change oil, check your lubrication chart to find out whether you have to change the grease too.

LUBRICATING TOOLS

Some lubricants are applied by smearing them on the surfaces to be lubricated. You will most often use a tool (grease gun, oiler, or grease pump) especially designed to put the lubricant into the equipment through a lubrication fitting.

Grease Guns

Grease is applied by a grease gun, or pump, through a nozzle that is designed to match the fitting. Although ordnance plants and repair shops have electrically or pneumatically powered equipment, you probably will have to depend on your own right arm for power to operate the lubricating equipment. Therefore,

in this section we will discuss only the hand-powered lubricating equipment you are likely to use.

Hand-operated grease guns are of two types, depending on how they are loaded. To load one style, you remove a cap that comes off with the handle and stem (fig. 12-3) and fill the body with grease, using a paddle or spatula. As you might expect, this method of loading can be messy; it also exposes the lubricant to dirt and moisture. A faster and cleaner kind of gun (fig. 12-3, view A) is loaded by removing the cap nut from the end of the hollow handle and forcing grease in through the handle with a handgun loader (fig. 12-4, view A) or a bucket type of lubricant pump (fig. 12-4, view B).

The handgun loader is a 25-pound container equipped with a hand-operated pump and a fitting that mates with the opening in the handle of the grease gun. The bucket type of lubricant pump makes use of a loader adapter and loader valve when it is used for loading a grease gun. One pound of lubricant is delivered with every seven full strokes of the pump. The loader will deliver lubricant only when the grease gun is placed on the loader valve. The job is much less messy with the loader, and it protects the lubricant against contamination. Besides, you do not have to run back to the storeroom to refill your gun.

Different nozzles can be attached to the grease gun for different types of fittings. The lubricant pump has

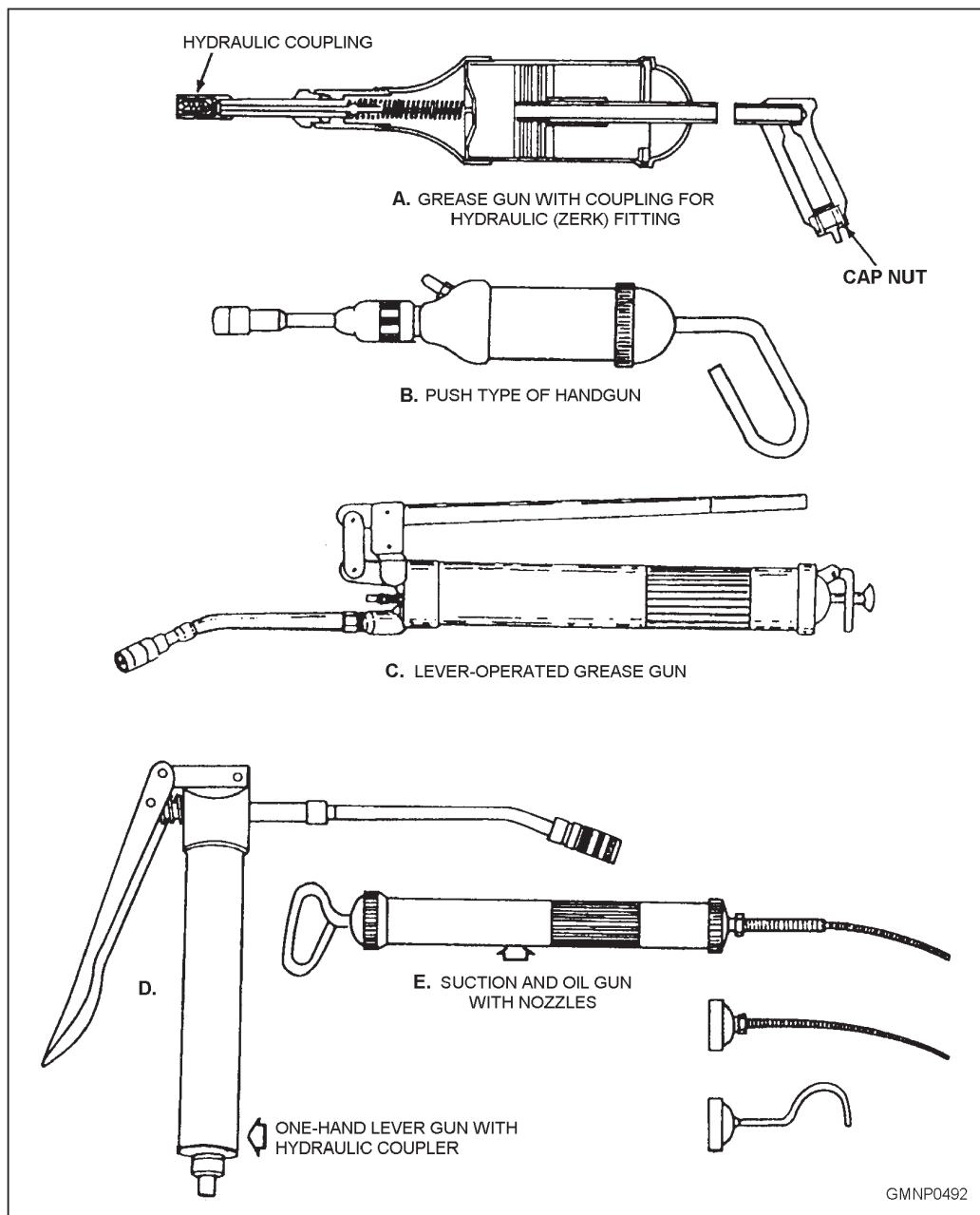


Figure 12-3.—Hand-operated grease guns.

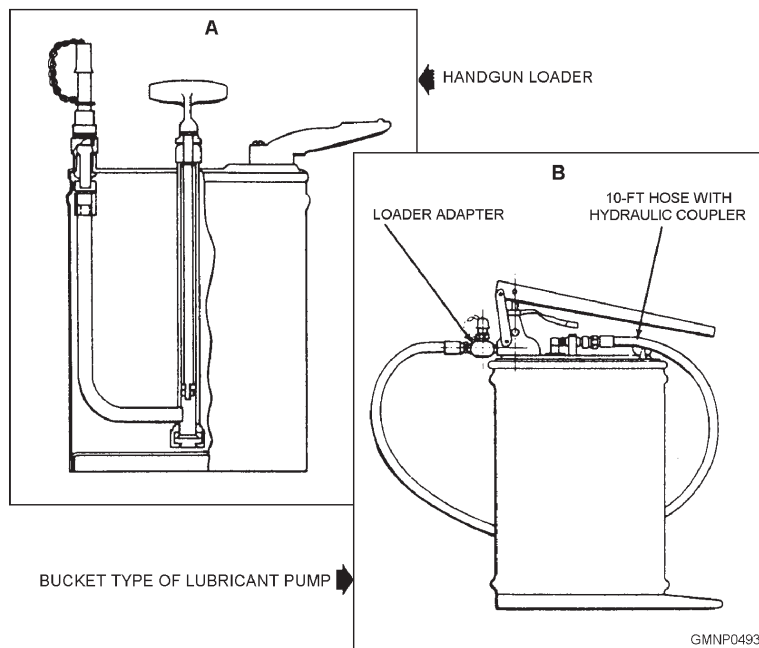


Figure 12-4.—Hand-operated grease pumps: A. Handgun loader; B. Bucket type of lubricant pump.

various couplers and adapters that attach to the hose, allowing the pump to be used on different fittings.

A grease gun can be used for oil if the point to be lubricated has the proper fittings, or an oil gun (fig. 12-3, view E) may be used.

A lever type of grease gun (fig. 12-3, views C and D) is being introduced; it gives more positive lubrication than the push type (Zerk) of grease gun.

When you need to apply large quantities of grease—as, for example, in a gun mount roller path—a grease gun is too small. The bucket type of hand-operated lubricant pump (fig. 12-4, view B) holds the same amount of grease as the handgun loader and is fitted with a pump operated with a lever. It has a 10-foot hose with a hydraulic T-handle adapter and a 90-degree adapter for working in cramped spaces. With this pump you can build up a lubricant pressure of 3,500 psi and deliver a pound of lubricant every 20 full strokes.

The hand-operated lubricant pump can handle any type of lubricant generally required on naval ordnance equipment except greases of the calcium soap type.

If you can arrange it, use several grease guns—one for each type of lubricant you will need. You can save time by taking care of all the fittings requiring a specific type of lubricant before going on to apply the next type. For example, if you are working on a 5"/54 mount, take care of all the fittings around the gunhouse that require MIL-G-81322 before working on those that take MIL-L-18486. After you have finished with the gun,

rammer, hoist upper end, and so on, repeat the sequence of application down in the handling room.

Fittings

Grease fittings are of several types—hydraulic (unofficially called the Zerk fitting, after its inventor), button-head, pin-head, and flush (fig. 12-5).

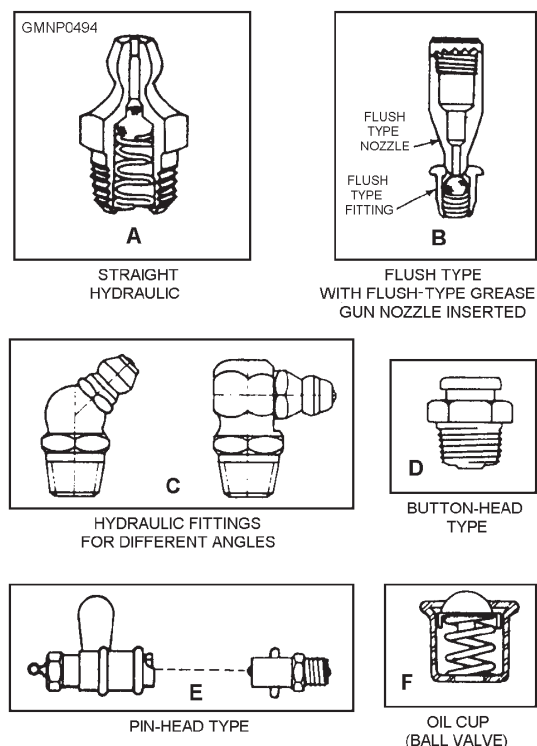


Figure 12-5.—Lubrication fittings.

The hydraulic fitting protrudes from the surface into which it is screwed and has a specially shaped rounded end that the mating nozzle can grip. A spring-loaded ball acts as a check valve. The nozzle will not slip off the fitting during lubrication but can be easily disengaged by a quick forward-backward movement. Figure 12-5, view A, shows a cross-sectional view of a straight hydraulic fitting, and view C shows hydraulic fittings made for different angles. They are made to fit almost any angle and have different threads and body lengths. When using a gun equipped with a nozzle for hydraulic type of fittings, just place the nozzle on the fitting and push forward on the handle. This slips the nozzle onto the fitting and, at the same time, builds up hydraulic pressure in the gun, forcing the grease out of the nozzle. Then relax the pressure. A spring forces the handle back, ready for the next stroke. Three strokes are usually enough. Only one hand is needed to work this type of gun. The grip action of the nozzle coupler holds the nozzle firmly to the fitting until it is pulled free. Hydraulic fittings are being replaced by commercial button-head and pin-head fittings (fig. 12-5, views D and E) that provide more positive connection with the grease gun. The grease gun can be used with the button-head fitting by adding an adapter.

The flush fitting (fig. 12-5, view B) is flush with (or below) the surface into which it is set so that it will not foul moving parts. It is also used where there is not sufficient clearance to install protruding fittings. The flush fitting also has a ball type of check valve. When pumping lubricant using a gun equipped for the flush type of fittings, you must exert a steady pressure against the grease-gun nozzle to keep it in contact with the flush fitting, since the nozzle has no grip on the fitting. Otherwise, the method of use is much the same as with hydraulic fittings.

The oil cup with the ball valve (fig. 12-5, view F) is the most popular type for oil fittings.

As with other routine jobs, it helps to have a standard operating procedure that you can follow. Here is one that will be helpful:

1. First, consult the lubrication chart and locate the fitting.
2. Clean the fitting carefully with a lint-free cloth.
3. Apply the correct amount of the specified lubricant. (Be careful of the amount you apply—too much will cause excessive heat in the bearing and strain the grease retainers, while too little is on a par with too late.)

4. Wipe all excess grease from around the fitting.

5. Check off the fitting on your chart. A fitting must not be missed just because it is battered or frozen. A frozen fitting could mean that the lubricant holes throughout the bearing are clogged. This means tearing down the bearing and cleaning all parts carefully. Grease that fitting even if it requires an hour of extra work. This is where a little extra tenacity can pay big dividends later by preventing a major casualty. Plastic protective caps are often provided for fittings. These caps keep out contaminants and also aid in keeping the grease in the fitting.

LUBRICATION CHARTS

Frequent reference has been made to the lubrication charts. They are published in the OPs for older ordnance equipment and on MRCs for all ordnance equipment. These charts are necessary to do your maintenance job properly. Copies of some charts may be obtained for use as checkoff lists. A sample chart is reproduced in figure 12-6. On it, you can see the use of target symbols (Nos. 1 and 2) and schedules for lubrication. Large equipments have several charts or MRCs with numerous places indicated for oiling or greasing. It would be easy to forget some places or to use the wrong lubricant if you did not have the chart or MRC to guide you and to check off as you work.

Lubrication Symbols

On lubrication charts and MRCs, lubricants and hydraulic fluids are identified by symbols, each symbol signifying a specific oil or grease. Examples are shown in figure 12-6. The symbols are identified in OD 3000.

Alternates and Substitutes

If the lubricant prescribed in the OP or MRC for a piece of equipment is not available, you may find it necessary to use either a substitute or an alternate lubricant.

A substitute lubricant is one that will fill the need for a limited time but does not have all the essential properties of the prescribed lubricant. As soon as the prescribed lubricant becomes available, all of the substitute must be removed, and the equipment must be completely relubricated with the prescribed material.

An alternate lubricant is one whose characteristics closely resemble those of the prescribed lubricant so that its removal is not necessary when the prescribed material is available.

Alternates and substitutes for prescribed lubricants (as well as for cleaning materials, hydraulic oils, and preservatives) are listed in OD 3000. If none of the alternate lubricants are available, you must choose a substitute. Keep in mind that the substitute should be as near as possible to the specified lubricant in lubricating and rust-preventive qualities, viscosity, and ability to withstand the temperature ranges of the equipment. In brief, when the prescribed lubricant is not available, use an alternate if you can, a substitute if you must.

STOWAGE OF LUBRICANTS

Lubricants and related materials may be stowed for long periods before use. Although they are relatively stable, they are not inert, and proper stowage methods are important.

Many factors contribute to the deterioration of materials in stowage. The nature of their constituents makes them more or less susceptible to chemical and physical changes. These changes are accelerated by elevated temperatures, humidity, exposure, and the presence of certain catalysts. The principal physical changes are separation and contamination.

Oxidation is the most common chemical reaction in stowed materials. It occurs when the material is exposed to air, particularly moist air, and is accelerated by high temperatures and the presence of certain catalysts. Materials containing soluble additives may deteriorate by decomposition or precipitation of the additive. These and other chemical changes can produce such harmful substances as acids, gases, water, insoluble gum, and sludge. Animal and vegetable oils are generally more susceptible to chemical change than mineral oils.

Physical changes include separation of oils from the soap component in greases and separation of insoluble additives from the parent material in oils. These changes may not be as serious as chemical changes, since a thorough mixing may restore the material to a usable state.

Rain, melted snow, and water vapor in the atmosphere can contaminate materials that are exposed or improperly sealed. Water vapor trapped in the container before sealing can condense when the ambient temperature drops.

Generally, containers used to package materials supplied under specification requirements are suitable for stowage purposes. The effects of overheating,

insufficient ventilation, and proximity to dangerous materials must be considered when handling and stowing lubricants and related materials. Good housekeeping in handling and stowage areas should be stressed at all times.

Containers, when stowed, should be handled carefully to avoid breakage. If they are stacked, overloading of the lower ones should be avoided, as this may open seams and permit loss of material. To prevent accumulation of water in their upper ends, you should stow drums on their sides. Lubricants and related materials should be segregated from explosives and other dangerous materials.

Before containers are stowed, they should be inspected for corrosion, leakage, and complete closure of all plugs, caps, and covers. All corrosion should be removed and the affected areas repainted.

During stowage, containers should be inspected frequently for leakage and corrosion. If tests indicate that the contents of leaking containers are in satisfactory condition, the materials should be transferred immediately to serviceable containers. The leaky containers should be removed and destroyed.

Stowage areas should be inspected for adequate drainage, foundations, and properly placed under undamaged tarpaulins. Any deficiency found during inspection should be corrected immediately.

Vapors from oils, greases, solvents, and similar products are flammable. When the vapors are combined with air in certain concentrations, they may form explosive mixtures that can be ignited easily by a spark, an open flame, or a lighted cigarette. To prevent accumulation of flammable vapors, you must ventilate stowage areas properly. To safeguard against fire and explosion, you should display warning signs prominently. Keep oil-fire extinguishing equipment available, and keep interiors of stacks open to permit entry of fire-fighting equipment. Only spark-enclosed forklift trucks should be used.

Flammable materials, such as oils, greases, and solvents, packed in metal containers or overpacked in fiberboard or wood boxes, are best protected when stowed in prescribed areas. Your ship should have an authorized stowage area for lubricants and other flammable materials. You may find it tempting to stow your often used grease gun and oil can in or near the gun mount. This is a dangerous practice and should be avoided. A temperature range of 40°F to 80°F is the most desirable for stowage.

Vapors from lubricants and related materials may frequently have a toxic effect on the human system. Every precaution should be taken to prevent excessive concentrations of such vapors in the air.

The following safety precautions should be observed when you are working with materials that have toxic effects:

1. Provide sufficient mechanical ventilation to reduce the concentration of toxic fumes to a safe level. When possible, ventilation should include an exhaust for fumes as well as intake for fresh air.
2. When a safe level of ventilation is doubtful, workers in the compartment should wear an air line respirator provided with a pure air supply.
3. Personnel working in a compartment where fumes may be above a safe toxic level should always work in pairs so that one person remains outside the compartment as a safety watch at all times. The person outside should have a respirator in case it is necessary to enter the compartment to bring out someone who has been overcome by toxic fumes.

In addition to the use and stowage of lubricants, new regulations are in effect that prescribe how lubricants are to be disposed. This includes oil- and grease-soaked rags. Your ship will have an instruction that details the disposal of these materials. As a petty officer, you must see that the regulations are observed by your personnel.

CORROSION CONTROL

Every member of the crew is expected to maintain his or her living spaces. Therefore, besides the technical maintenance details on your gear, you will also be responsible for cleaning, painting, and similar housekeeping work. It is the duty of the division officer to supervise the maintenance, the preservation, and the cleanliness of all spaces and equipment assigned to the division, but the actual tasks are usually assigned by the division LPO (this may be a PO3 or PO2). That means you have to know how to do the work and be able to teach others. *Basic Military Requirements*, NAVEDTRA 12018, chapter 19, describes general housekeeping preservation, procedures, and requirements.

As a GM, most of your cleaning and preserving work will be done on metal surfaces, principally steel. The preservatives must protect the metal against rust and corrosion; the cleaning materials must clean the surface before the preservative is applied.

Rust is caused by the slow burning (oxidation) of iron. When iron or steel rusts, it combines slowly with the oxygen in the air.

Technically, corrosion is not exactly the same as rust since its meaning includes metal being eaten away by acid or by the action of salt water or other substances. Rust and corrosion are dangerous and destructive saboteurs that attack unguarded metal at the slightest opportunity.

The way to protect metal from rust and corrosion is to protect it from the air. Paint is a good protective, but many metal surfaces, such as moving parts, cannot be painted.

The lubricants used on moving parts serve as rust preventives to some extent, but often this protection is not enough. These are temporary preservatives for protecting metal from water and weather. Light oils and greases are applied to exposed gun parts and mounts as temporary protection against corrosion. Bright steelwork, such as exposed cam and linkage surfaces, should have such protection. Slushing oils, available in several grades, are provided for this purpose. All old oil and dirt should be cleaned from the part and the surface thoroughly dried before new oil is applied.

Authorized Cleaning and Preserving Materials

Some lubricants (preservative lubricating oil for use in small arms and light machine guns) have preservative additives (rust inhibitors) and can serve for short-term preservation, but no preservative is intended for use as a lubricant.

When lubrication is not desired, there are special preservatives (permanent type) that may be brushed or sprayed on the surface to be protected. Small parts of a mechanism may be dipped. After treatment, the preserved mechanism can be stowed for a long period. (The length of time depends on the characteristics of the preservative, the kind of stowage, and so forth.)

A rust preventive that can be used either to protect exterior surfaces or (as when pumped through a hydraulic system) for preserving interior surfaces, tubes, and so on, is the thin-film compound, MIL-C-16173, that is available in several grades. A hard-film compound is available for metal exterior surfaces only.

Rust preventives are not lubricants and should not be used instead of lubricants. Before treating metal surfaces with rust preventives, be sure to remove all traces of rust and corrosion and all the old lubricant.

Be sure to remove all of the rust preventive before adding lubricant to ordnance equipment that has been stowed with rust-preventive compound coating. OP 1208, *Instructions for Inactivation, Maintenance and Activation of Ordnance in Vessels in Inactive Status*, gives step-by-step instructions for removing preservatives from gun mounts and other ordnance equipment. Chapter 5 of OD 3000, *Lubrication of Ordnance Equipment*, deals with cleaners and preservatives. It contains a chart of all of the cleaning and preserving materials authorized for use on ordnance materials. This chart gives the specification number, characteristics, applications, national stock number, container size, and substitutes, while the text elaborates on the use of each item. Some of the materials will be described very briefly in the following pages.

Dry-cleaning solvent P-D-680 (Varsol or Stoddard solvent) is useful for cleaning away old grease, oil, and rust preventives. However, it is hard on rubber (use soap and water on that). Because of its irritating, flammable fumes, it should be used only where there is plenty of ventilation and where there are fire extinguishers handy. Diesel fuel or kerosene can also be used for the same purposes as dry-cleaning solvent. The correct solvent must be used since some solvents leave a residue or cause corrosion. Therefore, always check the OP for the equipment.

Spraying or splashing of the solvent must be avoided during cleaning. If the solvent were to fall upon a bearing surface, it would cut or render the lubricant less effective, causing excessive wear. After the solvent has been used, the parts must always be wiped dry with a clean, lint-free cloth.

Removing Rust

When using abrasives to remove rust, be careful to select the proper type (see OD 3000) and use it sparingly.

Never use abrasives without permission from the proper authority. Only experienced personnel may use abrasives or wire brushing. Carelessly used abrasives can do more damage than rust. A few strokes of even a fine abrasive could destroy the accuracy of many close-fitting parts that are machined to close tolerances and could lead to costly replacements. Always be extremely careful to keep grit from getting into bearings or between sliding surfaces.

After the rust has been removed, the parts must be thoroughly cleaned and dried. Avoid leaving your

fingerprints on the metal. Cleaned surfaces should not be touched by bare hands before the rust preventive is finally applied. When the surface is clean and dry, you are ready to start applying paint or a preservative.

Painting Pointers

Painting is one of your important maintenance jobs. Instructions for using the chipping hammer in preparing metal surfaces for painting are outlined in *Use and Care of Hand Tools and Measuring Tools*, NAVEDTRA 12085.

Except for special applications like camouflage, the primary purpose of painting in the Navy is for preservation, rather than decoration. You do not paint just for the sake of appearance nor as a substitute for cleaning. When you do paint, you should do a thorough and neat job. "Thorough" means that you cover every square inch of the surface to be painted, and "neat" means that you keep paint off places where it does not belong. You have learned from past experience that it is much better and easier to keep the paint off the places where it should not be than to clean it off later. Always keep paint off gaskets, brightwork, grease fittings, rubber parts and rubber-covered wires, electrical leads and contacts not protected by armor or conduits, instruction or data plates, and working parts of surfaces that are normally supposed to be protected by a coat of lubricant.

The first thing to do when you are given a painting job is to remove the old paint, which you have been taught to do properly. The paint stripping solution recommended in OD 3000 is 8 ounces of sodium hydroxide (O-S-598 Type 1) in 1 gallon of near-boiling water. Rinse it with clean, hot water after the paint is removed. O-S-598 should not be used on aluminum, zinc, tin,terneplate, or lead.

Before applying paint, be sure the surface is clean and dry. Paint will not adhere to damp or oily surfaces or to surfaces covered with dirt, rust, or solvent. Galvanized surfaces must be wiped with ammonia, vinegar, or a special priming solution called wash primer before the paint will adhere. Brush the solution on, allow it to dry, and then wipe it off. Never use an abrasive on galvanized surfaces.

Soap and water are one answer to the problem of removing all dirt and traces of old oil or grease from metal surfaces to be treated with rust preventives, paint, or other preservatives. Wash away all soap; then see that the surfaces are dry; and, finally, apply rust preventives (or paint) without delay. It is sometimes hard to get at

pockets or cavities where water collects; be sure they are not neglected.

The standard finish for United States naval ship superstructures is a gray paint; the exact color and composition are prescribed by NAVSEA. You will also use gray paint for the exterior of gun mounts.

A prescribed gray-blue paint is used for exterior steel decks. Interior bulkheads and overheads are painted with a white paint prescribed by NAVSEA, and interior steel decks are usually finished with gray deck paint, although white is prescribed for decks in ammunition spaces. These are the general rules for painting; you will receive details on painting jobs from your leading GM.

BARREL MAINTENANCE

LEARNING OBJECTIVES: Describe the required care and maintenance of naval gun barrels and the purpose of using the proper tools, gauges, and inspection instruments.

Every gun used in the Navy has a bore and chamber. Taking care of them is one of the first duties of the Gunner's Mate.

Care of the bore and chamber is no once-a-year or once-a-month matter. They must be cleaned, dried, and inspected before firing. They must be cleaned, inspected, and oiled weekly. They must be gauged periodically, and the bore must be decoppered when necessary. Maintenance of the bore and chamber is an important job—not ordinarily a very difficult one, but one that must be done properly and at the prescribed times.

Frequent reference has been made throughout the manual of the need for keeping your guns cleaned and lubricated. This has been done for a purpose—the need to emphasize the importance of your job in keeping your equipment "fire-ready."

TOOLS USED

With the exception of one or two small-arms weapons for which maintenance tools are usually issued separately, every naval gun is equipped with certain basic maintenance tools and accessories. Larger guns and mounts are, of course, equipped with more elaborate sets of tools, but all sets include, as a minimum, the implements that are required for care of the bore and chamber.

Cleaning Gear

The bore and chamber maintenance tools and accessories issued for the 5"/54 are typical of such implements. The wire bore brush (with the sectional handle), the bristle sponge, and the lapping head are the basic cleaning instruments.

The sectional handle is a wooden rod with couplings at both ends that can be fitted either to similar couplings on other sections or to bore maintenance tools, like lapping heads and gauges. In the 5"/54 set, there are several of these sections supplied so that, by joining one to the other, you can make a pole of any appropriate length for the job at hand. The number of sections supplied with any gun makes any part of the bore accessible.

The bristle sponge is a cylindrical brush used for cleaning the bore and chamber. It fits onto the end of the sectional handle. When stowed, it is covered with a canvas protecting cap.

The lapping head is a cylindrical block on which can be mounted four removable spring-loaded segments. It is intended for removing relatively slight constrictions in the bore. In stubborn cases, you will need to use the wire bore brush. Its stiff steel wire bristles are effective in all but the very worst cases.

The tompion is used to keep dirt out of the gun bore and chamber. It is not used when there is a likelihood of condensation forming in the barrel with the muzzle plugged. It is also not used in wartime when there might not be time to remove it before firing. Sometimes plastic or canvas covers are used over the muzzle; the guns can fire through them if necessary (unless heavily ice-coated or if supersensitive nose fuses are used).

Gauges

The bore plug gauge is a metal cylinder accurately machined so that it just passes through the bore when the gun is new. After the gun has been put to active use, constrictions may develop in the gun bore. The bore plug gauge is used to locate these constrictions. On guns of 5 inches or smaller, the bore plug gauge fits onto the end of a section handle in the same manner as the previously covered accessories or is attached to a line and pulled through the bore.

The bore erosion gauge is used in the gun barrel to measure the amount of erosion of the metal caused by firing.

NOTE

The Mk 9 Mod 0 projectile seating distance (PSD) gauge was developed to replace the 5" Mk 2 bore erosion gauge for estimating velocity losses and percent-expended conditions in all 5"/54 gun barrels.

The PSD gauge is similar in construction to the old Mk 2 bore erosion gauge. The major difference is that the PSD gauge measures the seating location of the projectile, rather than the wear near the origin of the bore. For instructions and use of the Mk 9 Mod 0 PSD gauge, see OP 1549, NAVSEAINST 8300.1, and MRCs.

Inspection Instruments

Visual inspection of the bore and chamber precedes and follows cleaning operations. A light, of course, is very helpful in finding inadequately cleaned areas, pitted areas, rust or corrosion, deformed lands or rifling grooves, cracks, or other deviations. A bore searcher is used on 20 mm and larger guns. Look for corrosion at the muzzle end caused by salt spray.

If the chromium plating in the chamber of the bore appears pitted, the combat systems officer will decide if it is bad enough to need replating.

PREPARATION FOR FIRING

To prepare the gun for firing, you must inspect and clean the bore and chamber. Removal of the lubricant and the muzzle cover, or tompion, is but one of the operations in the preparation for firing.

Removing the muzzle cover, or tompion, is easy. To clean out the bore, however, you must wipe away the lubricant coating. In small arms, as you remember, this is done with a cleaning rod and a patch. In larger guns, you use the sectional handle instead of a cleaning rod and clean toweling wrapped around the bristle sponge in place of the patch. But the idea is exactly the same.

These instructions apply to guns that have been in use and were given afterfiring care when last used. If you are preparing a gun barrel that has been taken from stowage or if it is a new one, you have much more work to do. The preservative used on new or stowed barrels must be removed with dry-cleaning solvent. When all the preservative has been removed, the solvent must be wiped out of the gun.

CAUTION

Observe ventilation and fire precaution rules when using dry-cleaning solvents. Remember also that solvents are drying and irritating to the skin and destructive to rubber and insulation.

AFTERFIRING CARE

Afterfiring care is more elaborate than prefiring care. Every time a gun is fired, something besides the cartridge case is left behind. Deposits of corrosive salts (powder fouling) are left on the interior of the bore and the chamber. As the rifling cuts into the projectile rotating band, some of the metal of the rotating band is left behind as a deposit of copper in the bore (metal fouling or copper fouling). Both kinds of deposits are harmful and must be removed.

Standard maintenance procedure (postfiring maintenance) is to remove the dirt and powder foulings by washing out the bore and chamber with a Break-Free solution (CLP#7) that cleans, lubricates, and preserves in one application. The gun is then secured until the next firing or a scheduled maintenance action. Pre- and postfiring barrel maintenance requirements are listed in detail on the appropriate MRC, normally a situation requirement (R) card.

WEEKLY MAINTENANCE

Weekly maintenance is principally concerned with inspecting the bore and the chamber for signs of corrosion and renewing the coating of oil. Decoppering and gauging may also be done at the time of weekly inspection although they are usually a part of the before and after firing routine. Weekly maintenance is particularly important during periods when the gun is not being fired every day.

GAUGING

The plug gauge, described earlier, is used with guns 3 inches and larger for detecting constriction of the bore. After the bore has been cleaned, attach the gauge to the extended sectional handle and pass it carefully through the muzzle until it clears the chamber end. If it passes through smoothly, the bore is not constricted.

If copper fouling has constricted the bore, the gauge will not pass. The next step is to mark the part of the sectional handle that is flush with the muzzle end to locate the constriction. Then draw out the gauge,

remove it from the sectional handle, and attach the lapping head in its place. Push it into the gun bore up to the mark you placed on the handle and rotate it in the constricted area. Use the cylindrical segments for the lands and the rifled segments for the grooves. A mixture of pumice and oil may be used as an abrasive. Continue lapping until the bore gauge will pass freely. Never try to force the gauge through the bore; it may stick, causing damage to both bore and gauge.

The plug gauge is the gauge you will use most in maintenance of gun bores. But there are other gauges—headspace gauges, breech bore gauges, and star gauges.

Information about the types and uses of gauges is in system Ops and ODs.

DECOPPERING

We have already described the use of lapping heads and a fine wire brush (0.003-inch wires) to remove copper deposits in gun barrels. If the constriction is not removed after a few trials with the lapping head, the decoppering head may be used. These are mechanical or abrasive methods.

If there is metallic lead in the propellant, there is much less copper fouling when the round is fired. That is why older propelling charges were manufactured with lead foil in the case. However, the lead causes flash, and the more lead, the brighter the flash, which you do not want. To keep the flash to a minimum, you must keep the lead in most charges to a minimum. Propelling charges now being manufactured contain lead salts for decoppering effect.

MAINTENANCE TOOLS

LEARNING OBJECTIVES: Describe the use of common hand tools, power tools, types of torque wrenches, and special tools used in gun mount maintenance.

You must be familiar with the techniques and tools required to maintain, repair, and adjust ordnance equipment. Further, a GM must be able to select the proper general-purpose tools and special tools and know the safety rules applicable to their use. Maintenance tools can be classified as follows:

General-purpose hand tools

Power tools

Measuring tools and gauges

Torque tools

Special tools

HAND TOOLS

General-purpose hand tools are hand-powered and hand-operated. They are designed to perform simple mechanical operations. Examples of typical hand tools are hammers, screwdrivers, and hacksaws. General information about hand tools is in *Use and Care of Hand Tools and Measuring Tools*, NAVEDTRA 12085.

POWER TOOLS

Power tools can either be electrically or pneumatically powered and are hand-operated. They are designed to save time and manpower. Examples of power tools used by the Gunner's Mate are soldering guns, electric drills, and pneumatic grinders.

MEASURING TOOLS AND GAUGES

Measuring tools and gauges are used for measuring and for layout work. Accurate measurements are essential for proper fitting and trouble-free equipment operation. Measuring tools and gauges range from a simple ruler to a highly accurate micrometer. *Use and Care of Hand Tools and Measuring Tools* gives a detailed discussion on all types of measuring tools and gauges that includes the common steel rules, calipers, micrometers, dial indicators, feeler gauges, and depth gauges. When studying *Use and Care of Hand Tools and Measuring Tools*, pay particular attention to reading micrometers and how to make feeler gauge readings. These two measuring tools are used for testing, checking, and adjusting many types of electrical, mechanical, and hydraulic units used with ordnance equipment.

TORQUE WRENCHES

There are times when, for engineering reasons, a definite pressure must be applied to threaded fasteners (nuts and bolts, as they are commonly called). This pressure can be properly applied by a torque wrench. Proper torque aids in the locking of all types of thread-locking fasteners. After tightening, nuts and bolts are held by the static friction of the nut and bolt head against the surface of the items being held together and the friction on the threads of the nut and bolt against each other. This friction is caused by the clamping force created by a slight stretching of the bolt when the nut is tightened. The metal, being slightly

elastic, will pull back toward its original dimensions, creating large clamping forces. Excessive tightening will cause the metal to pass its limit of elasticity and cause a permanent stretch.

The principle of torque is based on the fundamental law of the lever; that is, force times distance equals a moment, or torque, about a point. Torque is often called a torsional or twisting moment. It is a moment that tends to twist a body about an axis of rotation. For example, if a common-end wrench is used to tighten a bolt, a force times a distance, a torque is applied to overcome the resistance of the bolt to turning.

Figure 12-7 shows three torque wrenches—the deflecting beam, the dial-indicating, and the micrometer-setting types. The deflecting beam is probably the simplest and most common. The primary component is the beam or measuring element. It is made of alloy steel and may be round, double round, straight flat, or tapered flat. To one end of the beam is attached a headpiece containing the drive square (tang) and fixed pointer mounting. A yoke is attached to the other end. Mounted on the yoke is the torque scale handle and, when provided, the signaling mechanism. As a force is applied to the handle, the beam deflects with the scale. The pointer remains fixed; hence, a torque is indicated on the scale.

The torsion bar or rigid case dial-indicating type of wrench, also shown in figure 12-7, has its actuating element enclosed in a rigid frame with a removable access cover. The deflecting beam, used in some rigid case wrenches, is similar to that explained previously.

The third torque wrench shown is the micrometer-setting type. To use this wrench, unlock the grip and adjust the handle to the desired setting on the micrometer type of scale, then relock the grip. Install the required socket or adapter to the square drive of the handle. Place the wrench assembly on the nut or bolt and pull in a clockwise direction with a smooth, steady motion.

There are several different types of torque wrenches, but all of them have two basic parts—something that will deflect with the load and something to show how much the sensing element has deflected.

The torque wrench should be calibrated frequently. One that has not been recently calibrated and is not normally stowed in its protective case should be considered as a dangerous tool. You cannot expect to get a meaningful reading from a precision instrument that has been abused. The flat- and round-deflecting beam types will normally give true readings as long as their pointers indicate zero and the drive heads are tight. Because this type can be kept in calibrations, it is recommended for shipboard use.

Other types of wrenches that indicate by means of dial indicator or by releasing or signaling when a preset load is reached are more sensitive to shock and dirt, hence should be calibrated whenever possible. A minimum of 30 days between calibrations is recommended. Never check one torque wrench against another.

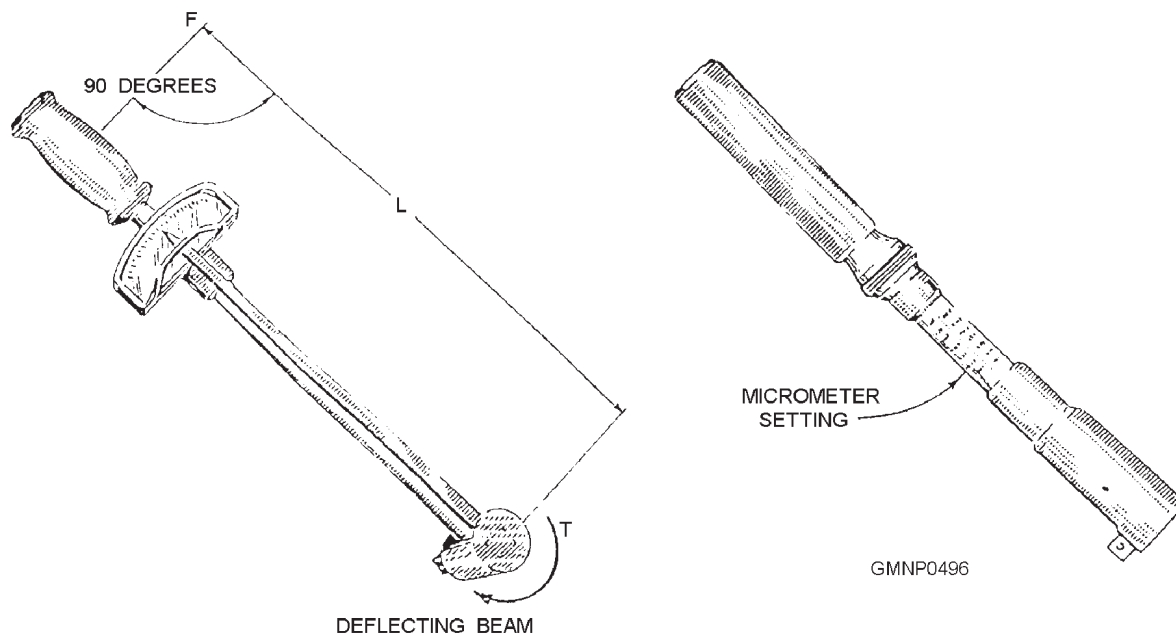


Figure 12-7.—Torque wrenches.

An important point to remember: always use the proper size wrench—the one with the desired torque near the three-fourths mark of full scale.

When torquing, the critical maneuver is the application of force to the wrench handle. It must be applied slowly and evenly until the desired torque value is indicated on the wrench scale. When installing a unit that is circular or has more than one side, you should cross-torque the bolts. It may be necessary to cross-torque two to three times before an even torque is reached, but be sure the maximum torque is not exceeded.

Nuts and bolts should be tightened to the torque reading required by the installation drawings. The formula often used is torque in foot-pounds is 0.2 times the bolt diameter times the desired bolt load. A load of about 60 percent of the yield stress of the bolt material is used for most naval applications. However, bolt load varies depending upon whether the bolt or stud is used to support the load itself or to hold together two load-supporting members. Installation drawings will indicate the torque value specified by the designer.

If the bolts are loaded in tension, the torque must be great enough to maintain tightness when the assembly is unloaded and not so large that the bolts yield under load. With this type of loading, all bolts must be equally torqued to share the load.

NOTE

Always inspect for clean, lightly oiled threads and clean surfaces before torquing. Discard all hardware with burred threads. For more detailed information on the use and care of torque wrenches, refer to *Naval Shops' Technical Manual (NSTM), Chapter 075*.

SPECIAL TOOLS

Special tools are used for one purpose and only on one type of equipment. They are supplied by NAVSEA, and instructions for their proper use are provided in the Ops applicable to the specific type of equipment.

NONSPARKING TOOLS

Nonsparking tools are common hand tools and special tools made from nonferrous metals (metal not containing iron). The Gunner's Mate uses these tools

when working on or around explosives. These tools are generally made from a copper alloy (bronze). However, they may be made from other nonsparking materials. Since these tools are made from a relatively soft material, care must be exercised when using them to prevent breakage or distortion of the tool. Nonsparking tools should be stowed in separate toolboxes and should not be used as common hand tools.

RULES APPLICABLE TO REPAIR TOOLS BEFORE A JOB

Before a job is started, all work procedures should be planned and the proper tools selected to complete the job. Tools not actually needed for a job should be properly stowed in toolboxes or tool lockers.

The quality and type of all tools must conform to Navy standards.

All tools in active use must be properly maintained. Defective tools should not be used.

Portable electric and pneumatic tools must be kept in the best condition possible. These tools should be checked frequently by the tool keepers for defective switches, electric cords, control valves, and hose connections.

Extensions to the tool handles should never be used to increase leverage.

PRESSURE GAUGES

Pressure gauges are used frequently in conjunction with ordnance equipment. Accurate pressures are necessary to obtain proper operation of hydraulic, pneumatic, and nitrogen accumulator systems used in ordnance equipment. Pressure gauges are also used with hydraulic test kits and magazine sprinkler systems. These gauges are the means of accurately measuring pressures in pounds per square inch (psi). Pressure gauges are used in weapon systems to measure hydraulic fluid pressures (oil gauge), magazine sprinkler system pressure (water gauge), counterrecoil system pressure (air gauge), and accumulator systems pressure (nitrogen gauge).

NOTE

Gauges used on weapons equipment are considered critical and require annual testing and calibration.

The two most common types of gauges used with ordnance equipment are the Bourdon and Schroeder pressure gauges. The theory of operation of these gauges is explained in *Fluid Power*, NAVEDTRA 12964.

The following are some precautions to be observed when using pressure gauges.

Do not allow pressure to remain on gauges that are permanently installed in hydraulic systems.

CAUTION

Never use a hydraulic fluid gauge for testing air pressure, nor an air gauge for testing fluid pressure. A diesel action may occur! Diesel action is the ignition of hydraulic fluid by air that causes combustion.

Never use a gauge on any system in which the maximum pressure exceeds the maximum designated range of the gauge.

SOURCES OF MAINTENANCE INFORMATION

LEARNING OBJECTIVES: Discuss the sources of ordnance data and maintenance information.

It would be impractical to try to squeeze into this chapter the many details you must know to perform maintenance, troubleshooting, disassembly, and reassembly to ordnance equipment assigned to you. Since there are many different marks and mods of equipment performing the same function but having different working parts, the Naval Sea Systems Command (NAVSEASYS COM) prints a publication requirement list for every active-duty ship now in service. This list is based on the major units installed and lists all the Ops, Ods, FMs, and TMs needed for repair, maintenance, test, and operation of these equipments. Copies of all the publications listed in this list are furnished to the vessel as part of the original commissioning allowance. If additional copies are required, they can be ordered through the appropriate supply point.

OP 0 is the index of the NAVSEASYS COM ordnance publications. It lists by number and subject the ordnance publications (Ops) and ordnance data (ODs) used in the Navy. OP 0 also lists all current revisions, changes, and supplements to OPs and ODs. In addition, it includes current Army field manuals

(FMs) and Army technical manuals (TMs) used by Navy activities. Your OP 0 may or may not be on microfiche.

ORDNANCE PUBLICATIONS

OPs are used by the operating forces and contain descriptions of ordnance equipment and their component parts and instructions on how to operate, maintain, disassemble, reassemble, test, and adjust the equipment. All OPs have a section on safety instructions for operating the equipment and general and specific safety orders when troubleshooting. The OPs are published by NAVSEASYS COM, each under its own OP number. Newer OPs are issued using the new Technical Manual Identification Numbering System (TMINS). As older OPs are updated, they are often converted to the new numbering system. They may be prepared by some other naval activity, by the manufacturer, or by the command itself. Any changes to OPs are issued by NAVSEASYS COM. Changes issued to the fleet are numbered and a record of all changes is listed on a change record sheet posted in the front of every OP. The information on these sheets includes the change number, the date the change was made, the title or brief description of the change, and the signature of the person making the change.

ORDNANCE DATA

ODs are a kind of catchall. They are used for publishing advance information or instructions on ordnance equipment installation and alignment data, parallax data, and other miscellaneous information, such as tables of weights and dimensions. ODs are numbered consecutively by the issuing agency. ODs, like OPs, are listed in OP 0.

One OD that is required reading for you and for all other Gunner's Mates is OD 3000, *Lubrication of Ordnance Equipment*. It is the one OD that your ship's library of ordnance publications must not be without. Other ODs may be useful to you, depending on the type of ship you are aboard and its armament. For this information you should consult OP 0. If the ODs are not already in your ship's library, they can be ordered.

Revisions

Revisions are made to OPs and ODs when the original publication becomes obsolete due to many design changes to the equipment. Revisions are numbered and the latest revision supersedes the previous one. When revisions of OPs are made

available, be sure you check the new OP for the purpose of the revision. In some cases, a revision may completely replace other OPs or ODs and their supplements. A statement in the front of each revised OP or OD identifies those publications that are made obsolete by the revision.

Changes

Changes may consist of pen-and-ink changes, complete page changes, or changes to drawings and sketches. Changes are made to OPs and ODs after Ordnance Alterations (ORDALTs) have been completed or when errors and inaccuracies are found in a publication.

Supplements

A supplement is an addition to an OP or OD that reflects changes to equipment or its operation made since the OP or OD was published. The original publications are still used; the supplements describe only the differences between the major assemblies or the differences between the marks and mods of gun mounts, missile launchers, and rocket launchers.

Supplementary Sources

At times, during the course of your work, you may require information not covered in OPs or ODs. Where you find this information depends upon the type of ordnance equipment with which you are working. If you are working with demolition equipment, for example, explosives ordnance demolition bulletins (EODBs) could help you. Other types of publications are special weapons ordnance publications (SWOPs), NAVSEA instructions and notices for general policy matters, and such other publications as ORDALTS-00 that supply information on all ORDALTs for aircraft, shore stations, and all classes of vessels.

The Army prepares several publications that are also applicable to Navy ordnance. These include field manuals (FM)s, technical manuals (TM)s, technical bulletins (TB)s, and joint publications of the Army, Navy, and Marine Corps. These publications are listed in the *Index of Doctrinal, Training, and Organizational Publications*, DA-PAM 310-3, U.S. Army, or SL-1-3, *Index of Publications Authorized and Stocked by the Marine Corps (PASMCMC)*.

ORDNANCE DRAWINGS

LEARNING OBJECTIVES: Discuss the main types of drawings used in gun maintenance and overhaul. Discuss the purpose of the illustrated parts breakdown (IPB) publication. Discuss the purpose of the standardized symbols used in hydraulic diagrams.

To do any kind of maintenance work on your equipment, you must know it well. A good way to learn about it is to study the hardware itself. But you will learn faster and you will learn more by using certain source materials. This manual is such a source; so are the OPs, ODs, and other publications. In many ways, however, your most valuable source material could be ordnance drawings.

All manufacturers of ordnance equipment make drawings of all equipments they manufacture. Copies of these drawings, reproduced by blueprinting, Xerox process, or in some other way, are supplied to every naval ship or installation that either has the equipment or, for some other reason, requires copies of these drawings. Many drawings are reproduced in OPs and other technical manuals. Some of the drawings you will use are made by NAVSEA, but many others are made by the contractors who manufacture the equipment for NAVSEA.

TYPES OF DRAWINGS

Drawings differ depending on their purpose. The main types of drawings, as classified according to purpose by NAVSEA, are as follows:

1. General arrangement drawings. This kind of drawing shows the complete equipment assembled. It indicates general appearance and relationships of important component assemblies and identifies the drawings that describe the components of the equipment.
2. Installation drawings. These drawings show such features as mounting pads and brackets, shock mounts, points for entrance of cabling and mating mechanical parts, type of cable required, dimensions of mounting hardware needed, and directions for how to orient the equipment and secure it to its place on the bulkhead or deck. One variety of this type of drawing, called an outline drawing, shows overall dimensions and clearances required for operating and servicing equipment.

3. Assembly and subassembly drawings. These drawings show the constructional details of the assemblies that make up the complete equipment. In general, you can think of an assembly (or subassembly) as any group of two or more parts assembled to make up a unit. An assembly drawing is intended to enable a properly equipped shop to make up the finished assembly from the prescribed parts and assembly and finishing materials.

4. Detail drawings. When you disassemble any piece of equipment far enough, you eventually get down to individual pieces that cannot be disassembled any further. These are represented by detail drawings that give all the information that a properly equipped shop will need to make the piece exactly as required.

5. Wiring drawings. The main purpose of a wiring drawing or diagram is obvious from its name—it shows you how to wire a piece of equipment or a system. There are several varieties of wiring diagrams.

An external wiring diagram shows how to connect an item of equipment to the ship's wiring system or to other pieces of equipment. It shows terminal boards, binding posts, plugs, jacks, and other connection points and devices, and identifies them by letters and numbers. Lines denote the electrical conductors to be installed. The drawing shows the size and type of wire to be used; the kind of insulation, shielding, ductwork, and armoring specified, as applicable; length needed; where ground connections are to be made; where joints must be soldered, welded, or clipped; and so on. It also specifies the kind of current (ac or dc), frequency, and voltage for each conductor.

An internal wiring diagram does the same for wiring inside equipment. It also identifies and shows where the fuses are, the size and type to be used, and their circuits. It locates and identifies, with standard symbols, all lamps, motors, synchros, resistors, capacitors, transformers, chokes, switches, relays, and all other electrical components in the equipment and gives their electrical values, as applicable. It identifies all the terminals and connection points. This is one of the most useful kinds of drawings for electrical maintenance and troubleshooting.

An elementary wiring diagram is about halfway between the diagrams we have just discussed and the schematic to be taken up shortly. It shows terminal and connection points, component locations and values, and so on, but it is also arranged so that it is much easier to follow and understand the circuit than with the usual

wiring diagram. But note that the elementary, like the pure schematic, has little respect for the actual sizes and shapes of parts or equipment or for their physical location or orientation. The traceability of the circuit is a much more important consideration.

6. Schematic drawings. About the only general statement you can make about schematic drawings or diagrams is that their primary purpose is to help the user understand the functioning of the equipment. In ordnance, schematics of electric, hydraulic, and pneumatic systems are of great importance in assisting you as a repairman. Schematics often have very little to do with the actual physical appearance or construction of the equipment diagrammed.

7. Lubrication drawings. A lubrication drawing or chart for naval equipment is often a general arrangement drawing, or a group of them showing several views, where lubrication fittings and other points are called out by labels. The OP on older equipment normally has a lube chart in its appendix.

8. Tool drawings. Special tools, such as spanner wrenches, for specific marks and mods of guns are described in tool drawings—usually assembly or detail type. These tools are listed in the specific OP.

9. Lists of drawings (LDs). LDs, as mentioned previously, are considered by NAVSEA to be a variety of sketches. In itself, this detail of classification is not especially important in your job, but it is worth remembering that an LD looks like and is treated like a kind of engineering drawing, rather than like a publication.

LDs are, in a sense, the key to the drawing system used by NAVSEA. Beginning at the top of the system, a master list of drawings, or master LD, is prepared for each major ordnance equipment (such as a gun mount). This list includes all components of the equipment concerned. Each component is itemized by assemblies, subassemblies, and details on a separate LD.

The identifying number for each component LD is given, together with the general arrangement drawing number on the master LD for the equipment. Each component LD also shows the special tools required for servicing that component. By reference to the LD and the drawings for the mark and mod of a given assembly or subassembly, it is possible to work down to an individual part and to identify the correct nomenclature, drawing, piece number, design dimensions, tolerances, and all other necessary information.

When we refer to a drawing or engineering drawing without qualification, we usually refer to an assembly, subassembly, or detail drawing. Such drawings, as we have seen, explain how to manufacture some part or assembly. And they are also valuable guides for you in overhauling and repairing equipment. These drawings are valuable not only because they show how parts fit (though this is very important itself) but also because they describe and enumerate the fastening hardware you need to put the assembly together (including the proper bolts, nuts, patent fasteners, pins, etc.). They also show the minor, but essential, parts that the assembly must have so that it will continue to function as the designer intended. A watertight enclosure, for example, will leak if it does not have the exact gasket called for in the drawing; screws may loosen if they have not been assembled with the lock washers specified in the drawing; and nuts will work free if they have not been secured with the cotter pins listed in the drawing.

Other types of drawings are equally valuable. General arrangement drawings are good references for the exact nomenclature of major units and as guides to drawings on component assemblies. Installation and outline drawings contain just the information on clearances and dimensions that ship's personnel require when a new piece of equipment is to be installed, and they show how to arrange the piping and wiring to be connected to it. External wiring diagrams show just how to hook equipment into the ship's wiring. After installation, they aid in troubleshooting for faulty circuits and malfunctioning components and in electrical alignment of synchros and other data transmission devices. Internal wiring diagrams are equally valuable for making circuit checks in case of trouble in the equipment. Elementaries are helpful in training personnel and can be used in checking circuits. And, finally, LDs are valuable guides in tracking down the particular piece of information you may be looking for.

Every ship carries copies of drawings on its equipment in the form of blueprints, photo prints, microfilm, or microfiche. These copies are assembled into sets, each set covering one item. Photo prints are usually bound in books. Aboard ship, both blueprints and photo prints are called ordnance drawings. Blueprints and photo prints are available to you either in a special file in the repair shop or in the custody of your department head. Make use of them; they will help you become familiar with the ordnance you will overhaul. (Remember to treat Confidential drawings as you would any other Confidential publication.)

Down in the lower right-hand corner of each drawing you will find a drawing number. On each detail pictured in the drawing, you will find another smaller number. These are the piece numbers. These numbers identify both the hardware and the drawing. Sometimes you will find a letter after the piece number showing how many times that piece has been changed or modified since the original design.

Every part of every ordnance device (unless it is very small) has a part number stamped on it. The first number is the drawing number; the second is the piece number. For example, you will find numbers like 120460-2. This should be read: "drawing number 120460, piece number 2."

Look for these numbers and use them. Refer to them when you report on a particular piece or when you order new parts.

ILLUSTRATED PARTS BREAKDOWN

An illustrated parts breakdown (IPB) is a publication usually in the form of an OP that describes and illustrates all components used in ordnance equipment. An IPB is broken down into sections that identify component parts by major assemblies, subassemblies, and detailed parts. All illustrations in these publications have figure and index numbers for proper repair part identification. The figure number represents a unit; the index number identifies just one part of that unit. Each unit has an identifying part number and accompanying each part number are the name and description of the part it represents. Part numbers are then cross-referenced to a current NSN to order replacements. The IPB illustrates the assembly of your equipment using expanded drawings. These expanded drawings are very helpful in locating lubrication fittings and other components that often elude a maintenance person.

Some IPBs have a cross-reference section that converts the identifying number to a part number or national stock number (NSN). These cross-references may not have the latest NSN; the appropriate section of the Coordinated Shipboard Allowance List (COSAL) should list all the latest NSNs. An index of IPBs is listed in OP 0.

HYDRAULIC DIAGRAMS

Hydraulic symbols are used throughout the world in design, operation, and maintenance of fluid power systems. A thorough knowledge of hydraulic symbols

will enable you to read and understand hydraulic circuit diagrams and other drawings of hydraulic circuits.

Hydraulics today have many and varied applications; therefore, a standardized set of symbols was agreed upon at a joint industrial conference of industry leaders. This conference recommended a system of designating symbols that some of the commercial manufacturers are presently using. These symbols for fluid power diagrams are listed in USAS Y32.10.

Graphic symbols provide clear-cut circuit information, and well-prepared circuit diagrams show every part of a hydraulic circuit clearly. Symbols are available for most commercial components. Drawings that use symbols will normally also supply a legend for their interpretation. *Blueprint Reading and Sketching*, NAVEDTRA 12014, and *Fluid Power*, NAVEDTRA 12964, give some elementary information on the theoretical background of drafting, on how to read drawings of all types, how to sketch, what type of information is found in a title box of drawings and schematics, and additional information on symbols used in electrical, electronic, and pneumatic sketches, schematics, block diagrams, and mechanical drawings.

PARTS NUMBERS

When ordnance parts are identified through the use of the IPB, ordnance drawings, or from part of manufacturer's numbers stamped on the parts, an NSN for each part is required before the parts can be requisitioned. These NSNs are listed in the COSAL that has a cross-reference section that converts a part number to an NSN.

The COSAL establishes the shipboard allowance for installed and portable equipment, equipage, and supporting material. Each COSAL is prepared for an individual ship and enables that ship to have a maximum self-supporting capability for an extended period of time.

Ships are issued a separate COSAL for each category of material. The index to all COSALs is issued by the Naval Supply Systems Command. Normally, one copy of the ordnance COSAL is kept by the supply department and one copy by the weapons or combat systems department.

If an NSN for a part cannot be found, the part can be requisitioned by the drawing and piece number and any other identification, such as the equipment's mark and mod, the manufacturer's name, the amperage and voltage rating, the name of electrical parts, and the serial number of the major unit from which the part was removed. Additional information about a part can also be obtained from equipment IPBs.

COMMON MAINTENANCE PROCEDURES

LEARNING OBJECTIVES: Discuss hydraulic and mechanical maintenance procedures, seal replacement, and special tools used on naval gun systems.

Traditionally, some of the most common preventive maintenance procedures have had to be learned by the maintenance person on the job. This is the case with replacing hydraulic seals and making mechanical adjustments. In this section we will provide you with some insight into the performance of these procedures. It may be helpful to have the maintenance manuals for your system handy to refer to as we go through these procedures. In all cases, you must consider the system maintenance manuals and maintenance requirement cards (MRCs) as your primary source of guidance and information. The information provided here is intended to augment and clarify these manuals.

HYDRAULIC SEAL REPLACEMENT

Most modern gun systems are loaded and positioned by hydraulic machinery. System pressures, in many cases, exceed 1,000 pounds per square inch (psi). As a Gunner's Mate performing routine maintenance on your gun, you need to be constantly on the lookout for hydraulic fluid leaking past the seals around pistons and operating shafts. When your system is leaking, it is telling you something. The seals are breaking down or are worn and could rupture at any time. Should the packings around a large high-pressure piston fail, you could dump 10 or 15 gallons of hydraulic fluid before the system can be secured. All leaks need to be reported, documented, and repaired as soon as possible.

Leak Documentation

When a leak is first discovered, it should be reported to your leading petty officer (LPO) and/or work center supervisor (WCS). Normally as the maintenance person, you will also be required to document the leak using the ship's 3-M Systems, Form 4790-2K. In the write-up, it is important to use proper terminology in describing the exact location and component where the leak exists. In describing what is required to correct the problem, it is helpful to include the part number and quantity of seals and other repair parts needed to do the job. Component names and part numbers are found in the IPB. Providing an exact description of the problem and the parts required to

effect the repair serves two purposes. If, for some reason, you are not available to help when the repair is scheduled, other maintenance personnel will be able to identify the problem and its solution easily. Second, when a problem is documented, it is incorporated into the *Current Ship's Maintenance Project* (CSMP). The CSMP provides Navy managers at all levels with information concerning the readiness of the systems aboard ships. It is used to plan and coordinate maintenance actions in the work center and to put together overhaul packages for completion by tenders and shipyards.

This documentation procedure not only applies to hydraulic leaks but to all other corrective maintenance you will perform. It is not normally necessary to document routine mechanical adjustments. However, if the adjustment is necessary due to replacement of a damaged or worn component, the circumstances surrounding the component replacement should be recorded.

Types of Seals

Before we go into the actual repair process, we need to describe some of the common types of seals used in ordnance equipment. A normal high-pressure packing consists of a U-Cup seal and a wiper ring. The U-Cup seal is installed with the cup facing the pressure it is to contain. As hydraulic pressure is applied, the cup fills and the sealing edge is held against the shaft or piston surface. The wiper ring keeps the piston surface clean to prevent wear of the U-Cup seal. These seals are often contained in an insert, called a packing gland, which is bolted or screwed into a valve block or cylinder. The packing gland allows for easy replacement of the seals since it can be removed. Figure 12-8 shows these seals and how they are installed in an actual valve block. The U-Cup seal is contained in a machined groove on the inside surface of the packing gland. The wiper ring is installed into another machined groove at the outside edge of the gland. Note the rubber O-ring seal in the machined groove around the outside

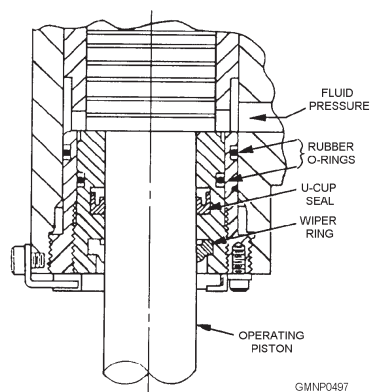


Figure 12-8.—A typical high-pressure hydraulic seal.



Figure 12-9.—Encased seal.

of the packing gland. Since both are machined to very close dimensions, an O-ring is sufficient to contain any seepage that may occur. O-rings are used throughout ordnance equipment in low-pressure sealing applications.

Another type of seal you may encounter is the encased seal (fig. 12-9). This type of seal is found where rotating shafts exit gearcases or other fluid-filled reservoirs. As the name implies, the seal is encased in a metal housing. Sealing surface tension around the rotating shaft is maintained by a spring located under the lip of the seal. The metal case of the seal allows it to be pressed into the component casing.

Seal Replacement

In replacing hydraulic system seals, you must take care not to contaminate the system. Contaminates in a hydraulic system can have devastating effects. Damage can range from accelerated seal wear to the total destruction of pumps, valves, and drive units. Using some simple precautions can help make sure your system remains free from contamination. First, make sure the area around the component you are going to disassemble is thoroughly cleaned. Second, after a component is removed, cover all exposed openings into the system with rags. Components removed for access can be reinstalled with their bolts turned finger tight. Reinstalling components and their retaining bolts also helps you to keep track of them. Last, make sure the component and the area it is to be reinstalled into are thoroughly cleaned. Anything you can do to limit hydraulic system exposure to outside conditions will help you maintain a system free of contamination.

Seal replacement often requires the use of special tools. A good example of this is the tool used to reinstall the packing gland over the end of the recoil piston (fig. 12-10). The tool is in the form of a ring, tapered on the

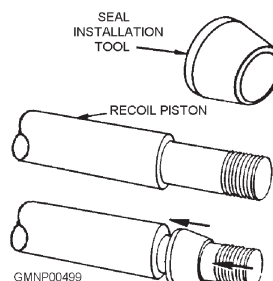


Figure 12-10.—Use for a hydraulic seal replacement special tool.

outside, that is slid over the threaded end of the recoil piston and up against the squared end of the enlarged section of the piston. The tapered outside of the tool allows the sealing surface of the U-Cup seal, which is fitted into a machined groove inside the packing gland, to slide easily past the squared end of the enlarged section of the recoil piston. The disassembly and reassembly of major gun system components are described in the system maintenance manual. Any special tools needed are identified throughout the procedure as required. All gun mount special tools are illustrated and described in the system maintenance manual.

The disassembly of hydraulic equipment inevitably causes air to get into the system. Your system will be fitted with vent plugs for releasing this air. Air is compressible and can cause your system to operate erratically or sluggishly. Be sure to follow the detailed instructions found in your systems maintenance manual or the appropriate MRC for venting air from the hydraulic system.

You may also find it necessary to replenish your system with hydraulic fluid after a repair is completed. The procedure for adding fluid to the system can be found both in the system maintenance manual and on a situation requirement (R) MRC. You will normally follow the procedure described on the MRC. Additional information on seals and seal replacement can be found in *Fluid Power*, NAVEDTRA 12964.

MECHANICAL ADJUSTMENTS

Gun loading system hydraulic machinery uses hydraulic pressure to position mechanical devices that move rounds of ammunition through the system for firing. Almost without exception, these mechanical devices must be adjusted to maintain travel and proximity tolerances to ensure proper performance. Some adjustments are verified during routine maintenance as part of the procedure contained on an MRC. Most often, however, you will need to make adjustments to mechanical equipment after it has been disassembled, repaired, and reassembled. Such is the case, for example, after a linkage has been removed to get to a hydraulic packing that required replacement or after a damaged component has been removed and replaced. You must refer to the system maintenance manual to determine the exact procedure and tolerances before making any mechanical adjustments. With this in mind, we will now provide you with some general information on the different types of mechanical adjustments found on gun mounts.

Clevis

The most common mechanical adjustment involves a threaded linkage that is screwed into or out of another component to adjust its travel or proximity to other components. Most mechanical linkages are connected to each other and to the components they control or operate with a clevis (fig. 12-11). A clevis is a U-shaped piece of metal with holes through the ends where a pin is inserted to attach one thing to another. The clevis is used as a flexible connection for mechanical linkages. It can be adjustable or nonadjustable and is often referred to as a yoke. The adjustable clevis may be either threaded through the base to allow for the insertion of a threaded shaft or it can be manufactured to include a threaded shaft. Often, the two configurations are used together as opposite ends of an adjustable linkage.

Threaded Shaft

Another common mechanical adjustment consists of an operating shaft threaded in one or both ends. A connecting shaft or actuator is screwed in or out of these threaded ends to adjust its travel or proximity to another component. This configuration can be used to adjust cam followers and mechanical actuators that push or pull a component to cause its operation (fig. 12-12).

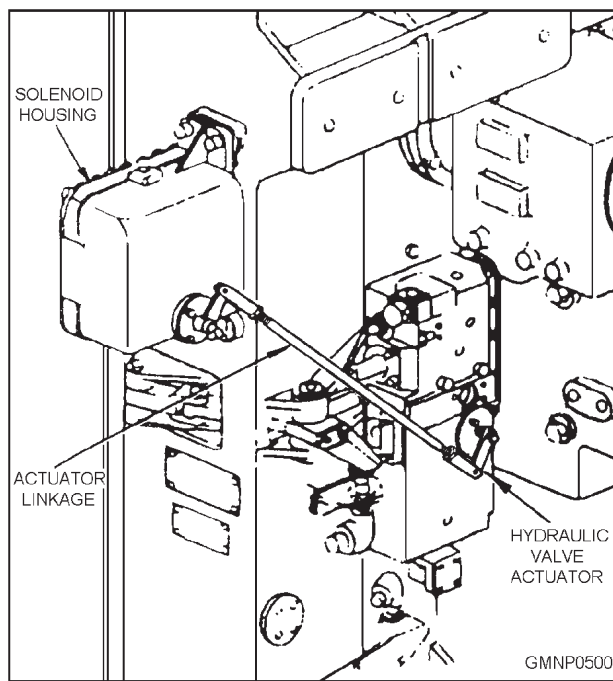


Figure 12-11.—The clevis.

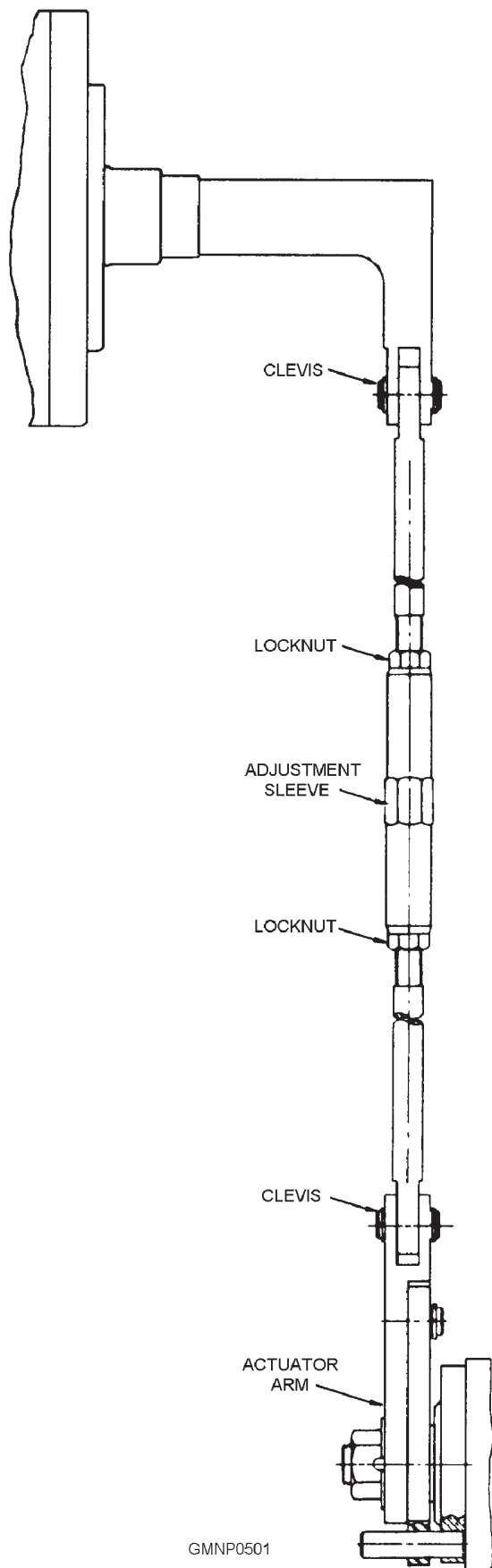


Figure 12-12.—Threaded linkage adjustments.

Eccentric Shaft

In some special instances a mechanical adjustment may involve shifting the rotational axis of a pivoting component. This is accomplished through the use of an eccentric shaft. An eccentric shaft, as shown in figure 12-13, is an otherwise straight shaft with an offset disk in the middle. The offset disk is the rotational axis of a pivoting component. Being offset, it allows this axis to be adjusted simply by rotating the shaft. In some cases, the eccentric shaft may be used as an adjustable securing pin instead of a pivot point.

Shims

Some gun mount adjustments are accomplished using shims. This is often the case when a major component is replaced and must be "fitted" into alignment or proximity with surrounding components. A shim is a noncompressible material, in sheet form, that is inserted between two components that are bolted together. Shim material is available in a standard pack of three different dimensions that can be cut and added together to achieve the desired thickness.

Hydraulic and mechanical maintenance is at the core of the traditional work of the Gunner's Mate. Mastery of hydraulic and mechanical maintenance, along with proficiency in troubleshooting electronic control circuits (chapter 5), is the defining characteristics of your expertise as a Gunner's Mate.

DAMAGE CONTROL PMS

LEARNING OBJECTIVES: Discuss the importance of divisional damage control on naval ships.

A common attitude throughout the fleet is that damage control (DC) is the responsibility of the engineers. As a result, the material condition of a ship frequently deteriorates due to a lack of attention to damage control maintenance at the various levels of performance. In fact, DC is an all-hands responsibility and should be performed and managed as such. What's the value of having a gun or radar working at 100 percent capacity if the ship is already sinking?

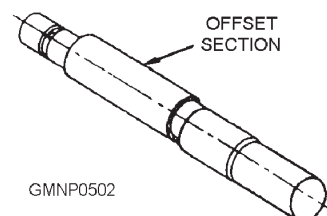


Figure 12-13.—Eccentric shaft.

A large amount of DC maintenance, such as weighing fire extinguishers or checking the operability of battle lanterns, are considered to be routine tasks and can be accomplished by just about anyone. Figure 12-14 shows a typical organizational structure of the DC PMS program aboard ship. As shown, a senior Hull Technician/Damage Controlman serves as the shipboard damage control work center supervisor. Each division assigns a damage control petty officer (DCPO) to the DC work center. The DCPO then performs the routine maintenance on the DC equipment located in his or her division spaces as assigned by the DC work center supervisor.

PMS schedules for DC are kept in nearly the same manner as regular PMS schedules and are maintained for the entire ship by the DC work center supervisor. Individual weekly schedules may also be maintained by the DCPO within his or her spaces in the division. Since the quarterly schedule lists each division assigned to perform DC PMS, it will not match the cycle schedule line for line.

Scheduling instructions for DC PMS is located in chapter 5 of OPNAVINST 4790.4. Shipboard damage control organization and requirements are outlined in *Surface Ship Damage Control*, NWP 62-1.

PMS MANAGEMENT

LEARNING OBJECTIVES: Discuss the importance of PMS management at shipboard

and type commander levels, and the definitions used to evaluate the PMS program.

One of the most important considerations in the operation of a PMS program is the proper management of that program at all levels concerned.

SHIPBOARD EVALUATION OF PMS

To have an effective maintenance program, you should be involved at all levels of management aboard ship in the supervision and evaluation of PMS. It can be safely said that every officer and most chief petty officers will be tasked with evaluating the accomplishment of PMS aboard their ship. A typical example of the structure of the 3-M organization aboard ship is shown in figure 12-15. As you can see, the majority of senior shipboard personnel are involved with PMS functions.

One of the best ways to evaluate the effectiveness of shipboard PMS is by conducting spot checks of individual maintenance requirements. As the leading GM, you may often be tasked with performing a spot check on a work center outside of your department. Table 12-2 identifies the minimum shipboard spot check requirements, who they should be accomplished by, and the periodicity at which they should be conducted.

The maintenance prescribed in the PMS package is defined as the minimum required. Therefore, a

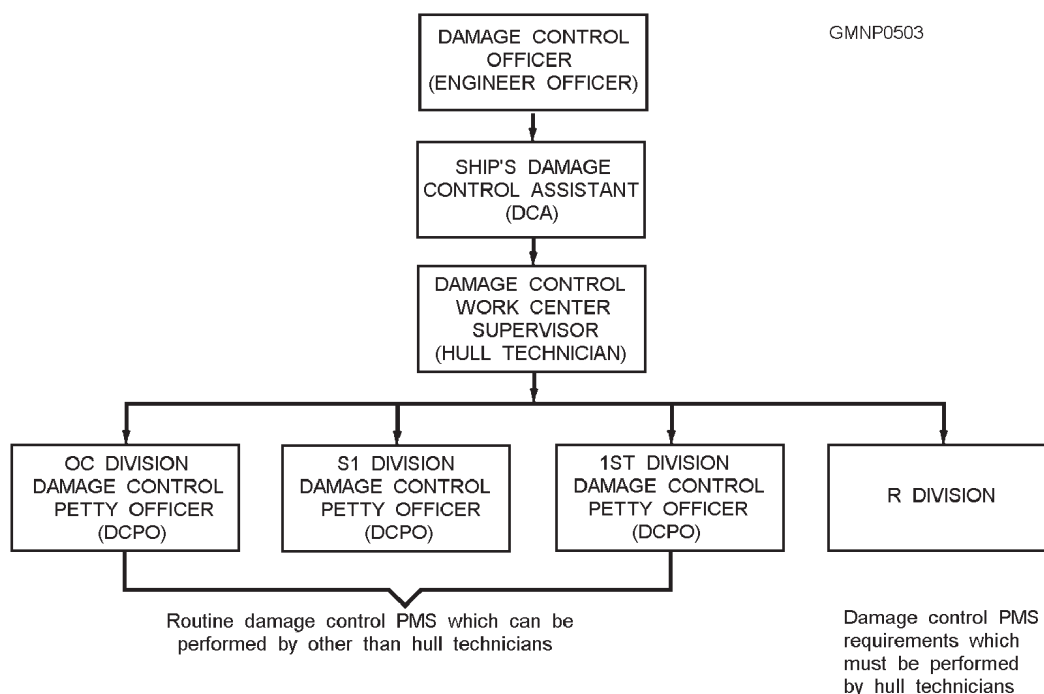


Figure 12-14.—Representative organizational structure for damage control PMS.

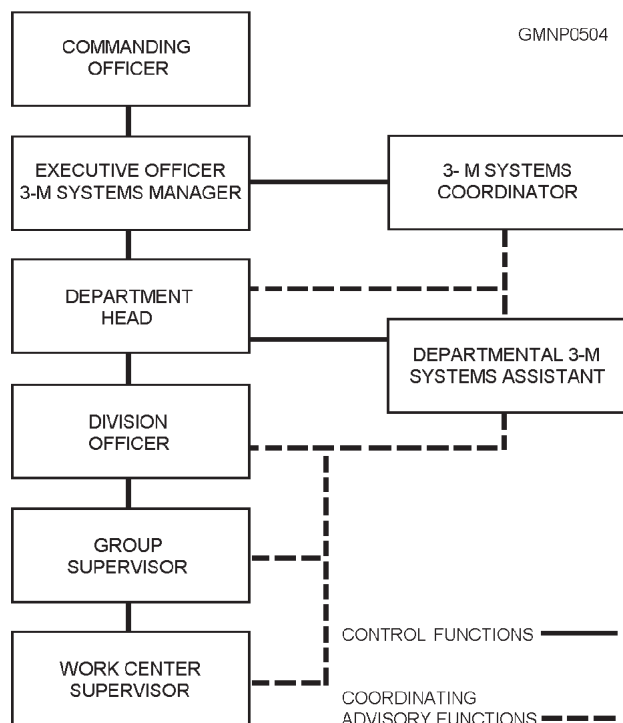


Figure 12-15.—Shipboard 3-M Systems organization.

maintenance requirement that has been deferred beyond its assigned periodicity is not considered to be accomplished. These deferrals will affect the accomplishment rate of the PMS of the work center and should be kept to a minimum. The work group or work center supervisor should know at all times what maintenance requirements have been deferred and for what reason(s).

TYPE COMMANDER EVALUATION OF PMS

In addition to shipboard evaluation, type commanders (TYCOMs) are also tasked with monitoring the effective management of PMS within their respective commands. The TYCOM conducts PMS inspections at periods of 18 to 24 months, using his or her own qualified inspectors, working in conjunction with the ship's 3-M coordinator and other shipboard managers as required. These inspections are conducted on a "no advance notice" basis. A PMS Performance Rate (PPR) of less than 75 percent is a

failing grade and will definitely bring down some high-powered attention from such people as your squadron or group commander.

To ensure standardization for the measurement of PMS performance, you should use the following definitions to evaluate PMS performance:

PPR—(PMS Performance Rate). This is an overall quantitative evaluation of the actual performance of the required maintenance planned for accomplishment.

RAR—(PMS Recorded Accomplishment Rate). This is the percentage of maintenance scheduled during the period of examination that is recorded as accomplished.

ACF—(PMS Accomplishment Confidence Factor). This is the percentage of maintenance recorded as accomplished that is evaluated as actually having been performed.

A—This is the symbol that identifies the number of maintenance requirements actually scheduled. It is used to compute the RAR.

B—This is the symbol for the number of maintenance requirements recorded as fully accomplished. It is also used in computing the RAR.

C—This is the symbol for the number of partials and is the final factor required to compute the RAR.

N—This is the symbol for the number of maintenance requirements evaluated by the inspector as not accomplished. It is used to compute the ACF.

P—This is the symbol for the number of maintenance requirements evaluated by the inspector as having been partially accomplished. It also is required to compute the ACF.

S—This symbol represents the number of maintenance requirements sampled by the inspector and is the final factor required to compute the ACF.

The ship's final grade is determined by computation of its PMS Performance Rate (PPR) as follows:

Table 12-2.—Minimum PMS Spot Check Requirements and Periodicity of Accomplishment

MANAGEMENT LEVEL	NUMBER OF MRs AUDITED	INTERVAL
Commanding Officer/ Executive Officer	1 per own ship	Weekly
Head of Department	3 per department	Weekly
Division Officer	1 per division work center	Weekly

First, you must determine the RAR by using the following formula:

$$RAR = \frac{B + \frac{C}{2}}{A}$$

Second, determine ACF by using the formula

$$ACF = \frac{\left(S - \frac{P}{2} - N\right)}{S}$$

Now you can determine your PPR by using the formula

$$PPR = RAR \times ACF$$

This system may seem complicated but is actually simple once you have learned to use it. You can use it to monitor your accomplishment rate, as well as to identify problem areas within your ship's PMS program. Detailed instructions on PMS inspections and their procedures are located in chapter 5 of OPNAVINST 4790.4.

QUALITY ASSURANCE

LEARNING OBJECTIVES: Discuss the quality assurance program, its importance, and responsibilities of the Gunner's Mate with respect to naval ordnance.

The Quality Assurance (QA) program is designed to provide the fleet with safe ordnance material of the highest quality in a timely manner. The basic priorities are safety first, quality second, and quantity third. The program is conducted when the material is acquired from the contractors and during receipt, production, maintenance, stowage, and issue of ordnance material at naval activities.

Quality assurance requirements and procedures ensure that:

1. Incoming ordnance material is of the designated type and quality; has not been damaged in shipment; is identified with the appropriate condition code status (serviceable, unserviceable, suspended, etc.); and is packed, packaged, and preserved as necessary. This will permit further processing in a safe manner and aid in the prevention of material damage or deterioration during stowage, handling, and issue.

2. Ordnance material is segregated into compatible groups by explosive content and condition code for stowage, further processing, or transshipment.

3. Ordnance material is controlled during handling and stowage to prevent the existence of unsafe conditions or degradation of serviceable material.

4. Periodic maintenance is performed as required and maintenance and renovation operations are controlled to ensure that ordnance material completing these operations conforms to all applicable specification requirements.

5. Only safe and serviceable ordnance material is issued to operational units.

6. Ordnance material destined for outload is packed, packaged, and preserved as specified in applicable technical documents and, after loading, is securely blocked, braced, and dunnaged in the carrier to facilitate safe transport.

ORGANIZATION AND RESPONSIBILITIES

The commanding officer of an activity has final responsibility for the quality of issued ordnance material. Weapons and ordnance personnel are responsible for ensuring the quality of ordnance material to be issued and for maintaining control of ordnance material throughout activity operations. The quality assurance organization within a command is responsible for providing assurance that the necessary controls are established and maintained and that ordnance material being issued meets specified quality requirements.

A quality assurance organizational element responsible for performing quality assurance functions on ordnance material is required at each activity. This quality assurance element must be established at a level that provides the organizational independence necessary to achieve full implementation of quality assurance procedures. Each activity must plan, establish, staff, and maintain the ordnance quality assurance organization commensurate with local work load. The head of quality assurance serves as the commanding officer's representative and reports directly to the CO.

At ordnance-oriented activities, such as naval magazines and naval ordnance facilities or naval stations, the ordnance quality assurance organization should be established as a division within the weapons/ordnance office. Another alternative at these types of activities is to include the ordnance quality assurance organization as a division within the QA department of the activity, along with quality assurance organizations for other programs.

Each division within the QA department must be divided into branches as necessary to perform the required QA functions effectively.

The head of an ordnance QA organization ashore may be military or civilian. However, it is essential that this person be well-qualified in ordnance QA procedures, methods, and techniques, in addition to being knowledgeable in the technical aspects of the specific ordnance material being processed. In any event, the individual must have the ability to plan and manage the ordnance quality assurance functions and train subordinate personnel as required. Collateral nonquality assurance functions assigned to the ordnance QA organization should be kept to a minimum. This is necessary to avoid detracting from the essential ordnance QA functions. Subordinate personnel must also have a good working knowledge of both the technical aspects of the material and ordnance QA procedures.

In some cases, because of budgetary, manpower, or other limitations, it may not be possible to establish a separate quality organization. In this case, qualified personnel from within the activity must be selected and trained to perform the QA functions. Such personnel should be permitted to perform the assigned QA functions without undue external pressure, the bias of inspecting their own work, and being held responsible for delays in production.

The weapons department should have an ordnance indoctrination/training program. The QA organization should provide the materials for the quality assurance segment of the indoctrination/training. The QA segment of the indoctrination may be accomplished by QA personnel or through normal activity training program procedures.

A list of military and civilian personnel whose work assignments may directly affect the quality of ordnance material must be compiled and the personnel scheduled into the indoctrination/training program. New personnel destined to perform work related to ordnance material should be scheduled into the indoctrination/ training program as they arrive on station. Weapons supervisory personnel and QA personnel must be constantly alert to the need for refresher training or other specific ordnance-related training requirements as evidenced by the quality of work performed. Weapons supervisors will ensure that the necessary on-the-job training (OJT) or classroom training is provided before assigning personnel to new jobs related to ordnance material processing. Records

of OJT and classroom training for weapons personnel must be prepared and maintained.

The head of the QA organization will schedule all personnel who will be assigned to perform QA functions into training in the content and application of the quality assurance procedures.

Each supervisor will provide OJT through rotational work assignments to provide increased range and depth to the capability of QA personnel. These periods of OJT should be of a sufficient duration to ensure that the trainee is fully qualified to perform his or her duties in that area of assignment.

CALIBRATION OF TEST AND MEASURING EQUIPMENT

QA must ensure that only currently calibrated test and measuring equipment is used to record or generate quantitative measurements or data during maintenance actions. Each QA inspector should verify that calibration labels and tags are affixed to all test and measuring equipment within his or her work area. The labels and tags must indicate that the equipment is in an "in-calibration" status or does not require calibration. Any discrepancies noted should be documented.

QA personnel should perform daily monitoring within each work area to ensure that only those gauges authorized for use by the ordnance work instructions are being used or are available for use by weapons personnel and that the gauges display current evidence of calibration. During these daily monitoring actions, QA should verify that all activity organizational elements properly use, handle, and stow these gauges.

QUALITY DEFICIENCY REPORTING

Information feedback is needed for corrective action purposes when deficiencies are found in material received as serviceable (RFI) from other activities or from the supply system. NAVMATINST 4855.8 establishes a DoD system for reporting quality deficiency data and provides the reporting procedures and forms for this purpose.

Quality deficiency reports are submitted to a screening point within the activity originating the report. Here, the responsible action point (activity responsible for resolution of the deficiency) is determined and the report is forwarded to that action point. Complete instructions on quality deficiency reporting are contained in NAVMATINST 4855.8. Only Category I reports will be addressed in this text.

A Category I report is submitted when a deficiency is found that might affect life or limb of personnel or impair the combat capabilities of the using organization or individual. Deficiencies that affect an operational capability to the extent that accomplishment of the mission is jeopardized are included in Category I.

Category I reports must be submitted by message. When urgency dictates, reports may first be transmitted by the most expeditious means available (e.g., telephone or local visits). Oral communications must be confirmed by a message. Information copies of Category I reports may be submitted to any activity considered necessary to alert them to the problem.

The originator of the Category I report must forward the report to the designated screening point within 24 hours after discovery of the deficiency. The report must be screened for completeness and accuracy and forwarded to the appropriate action point within 48 hours after receipt. The component or activity responsible for action must acknowledge receipt of each report to the screening activity within 24 hours.

SAFETY

LEARNING OBJECTIVES: Discuss the importance of observing proper safety procedures when working on naval gun systems and ordnance.

The primary reason for the vast amount of information available on the subject of safety precautions is simply the desire to prevent accidents. Research has shown that a majority of all accidents came about through sheer carelessness. Not only is there a loss of time involved in an accident but there is also an accompanying loss of equipment, material, or, in the extreme case, life itself. Aside from these important considerations, there is a vast amount of money wasted in replacing damaged equipment, making investigations, paying for hospitalization or funerals, and for man-hours not worked during convalescence. These are but a few of the problems faced every day by the Navy because personnel fail to heed the posted and required safety precautions.

Safety is everybody's job. Awareness of danger, knowledge of how to avoid it, and constant vigilance are the three basic requirements for the prevention of accidents while you are working on or operating ordnance equipment.

Safety is both a result and a reflection of good training. The crews of a gun mount may be trained so

that they know how to do their jobs; however, the crew still cannot be considered well trained unless each of them is safety conscious. Safe working habits must be impressed upon every crewmember through proper instructions, constant drills, and continuous supervision. Carelessness, cockiness, and lack of training have led to disaster while working with all types of ordnance equipment and materials.

Practical safety features are incorporated into Navy equipment to eliminate potential hazards to personnel. Since familiarity with equipment leads to carelessness, observation of all safety notices and rules is mandatory. No relaxation of vigilance should ever be permitted.

Each piece of ordnance equipment has a specific list of safety precautions to be observed during operation and/or maintenance. Study these thoroughly before attempting to operate or repair any piece of equipment that you are not familiar with.

The following safety rules are but a few of the many that must be observed when operating or working on hydraulic or pneumatic systems:

Never disconnect hydraulic lines or disassemble hydraulic equipment when the hydraulic system power motor is running.

Never disconnect hydraulic lines or disassembly hydraulic equipment until the accumulators have been manually dumped to the tank.

Never manually actuate switches, solenoids, relays, or valves on hydraulic systems under pressure unless you are competent and qualified to perform these actions.

Report hydraulic leaks immediately, so that they may be repaired at the first opportunity.

If clothing becomes drenched with hydraulic fluid, immediately change into dry clothing. Hydraulic fluid is injurious to health when in prolonged contact with the skin. It is also a fire hazard. Immediately wipe up all spilled fluid.

Do not direct a high-pressure air jet at any part of the human body; this may be fatal.

All personnel taking part in and observing operation of power equipment must remain alert, keep clear of moving parts, and be thoroughly familiar with the safety precautions applicable to that equipment. At no time should skylarking be allowed in the vicinity of operating power equipment.

Hydraulic systems operate under hydraulic pressures ranging from approximately 100 psi to 2,000

psi. Some pneumatic systems operate in approximately the same range of pressures as hydraulics. These pressures are dangerous and can be hazardous to personnel.

Safety precautions must be observed when performing maintenance, testing, and operating ordnance hydraulic and pneumatic equipment. The high-pressure liquid or air can cause major injuries to your face, hands, and other parts of the body by jets of air or liquid escaping from valves or pipe connections that are highly pressurized.

The following summary of safety precautions is intended to be general in nature, but its importance should not be misunderstood:

Do not service or adjust live equipment without the presence of another person capable of rendering first aid.

Never measure potentials over 600 volts by means of flexible test leads.

Do not tamper with interlocks or any other equipment safety feature.

If possible, use only one hand when working on live circuits.

Never use electrical or electronic equipment known to be in poor condition.

Do not allow unqualified personnel to operate the control panels. Trainees or other persons undergoing instructions should be allowed to operate control panels only under the strict supervision of a qualified and responsible operator.

Except for general quarters, always sound the train-warning bell and get an all-clear signal before training and/or elevating the gun mount (before each time the equipment is to be moved).

Whenever any power drive unit that is capable of inflicting injury to personnel or material not continuously visible to the person controlling such motion is moved, the officer or petty officer authorizing the unit to be moved by power must ensure a safety watch. The on-deck safety watch is not necessary during general quarters but must be maintained in areas where such injury is possible, both inside and outside the unit being moved. There should be a telephone or other effective voice communications established and maintained between the station controlling the unit and the safety watch.

The following are a few basic rules that you should keep in mind when using wrenches:

Always use a wrench that fits the nut properly.

Keep wrenches clean and free from oil. Otherwise, they may slip, resulting in possible serious injury to you or damage to the work.

Do not increase the leverage of a wrench by placing a pipe over the handle. Increased leverage may damage the wrench or the work.

Provide some sort of kit or case for all wrenches. Return them to it at the completion of each job. This saves time and trouble and facilitates selection of tools for the next job. Most important, it eliminates the possibility of leaving them where they can cause injury or damage to personnel or equipment.

Determine which way a nut should be turned before trying to loosen it. Most nuts are turned counterclockwise for removal. This may seem obvious, but even experienced personnel have been observed straining at the wrench in the tightening direction when they wanted to loosen it.

Learn to select your wrenches to fit the type of work you are doing. If you are not familiar with these wrenches, make arrangements to visit a shop that has most of them and get acquainted.

The following precautions should be observed when using torque wrenches:

Do not use the torque wrench as a hammer.

When using the micrometer-setting type, do not move the setting handle below the lowest torque setting. However, it should be placed at its lowest setting before being stowed.

Do not use the torque wrench to apply greater amounts of torque than its rated capacity.

Do not use the torque wrench to break loose bolts that have been previously tightened.

Never stow a torque wrench in a toolbox or in an area where it may be damaged.

Be thoroughly familiar with all posted safety precautions and those listed in the OP pertaining to the equipment to which you are assigned.

Do not think that once you have learned all applicable safety precautions you can sit back and take things easy. Review the precautions periodically, particularly those for jobs seldom performed. Try to improve upon any rules in effect. Safety is everyone's responsibility, not just those who developed the regulations. Most accidents are caused by personnel who are so familiar with their job they think they can

take shortcuts; by personnel who do not know the applicable precautions; by practical jokers; or, in the majority of instances, by plain carelessness.

PMS SAFETY

As in all other evolutions, the observance of proper safety procedures is also an important consideration when performing PMS. It is extremely important that personnel involved in maintenance are thoroughly trained in safety practices. Nothing can replace good common sense when performing any kind of task, but awareness of the specific hazards of a given job will save lives and prevent damage to equipment. Maintenance Requirement Cards (MRCs) have warnings and cautions inserted immediately before the procedural step they apply to and should be obeyed as closely as possible. Any discrepancies or inadequacies in PMS safety procedures should be reported immediately via an urgent PMS Feedback Report. *Navy Safety Precautions for Forces Afloat* (OPNAVINST 5100) contains safety instructions and precautions to be used when performing PMS.

SPECIAL SAFETY MARKINGS

Index marks and safety lines are painted on or near ordnance equipment and are used by the GM to indicate a complete mechanical function and to indicate safe areas.

An example of the index mark is the breech-closed index painted on the gun housing (fig. 12-16). The

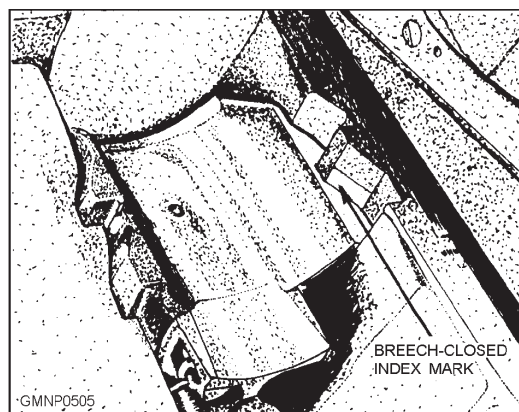


Figure 12-16.—Breech-closed index mark.

index mark shows at once whether the breechblock rises promptly to full breech-closed position, or is sluggish, or sticks. Some guns also have index marks on the housing and slide to indicate full return to the battery. These index marks tend to wear off and require periodical freshening up. Be careful not to get the paint on any other part of the sliding surfaces.

Safety lines mark off safe working areas. Circular safety lines are painted on the deck around a gun mount to indicate the areas you should stay out of when the gun is being trained. "Blast area" lines are painted on the decks around rocket launchers to show how far away you must get to be safe from the hot-rocket blasts. Similar safety lines are necessary to show safe working areas around overhead conveyors and other machines that may be dangerous to personnel who fail to keep away from working parts.

SUMMARY

Gun maintenance involves a wide variety of skills and knowledge. However, all of the skill and knowledge in the world are useless without a high degree of personal dedication to your job and the people around you. The dangers involved in gunnery are readily apparent. Your vigilance as a maintenance technician may well make the difference between a successful gunshoot or missile launch and a catastrophic accident. Take the time to learn your system and never assume anything.

In this chapter we have discussed the various maintenance requirements involved in keeping a gun and missile system operational. We described the important foundational role preventive maintenance plays in both system readiness and your personal development as a technician. We described the lubricants and tools used in routine maintenance as well as the reference publications that provide in-depth information about the operation, upkeep, and repair of your gun or launcher. We described some specific maintenance actions that you will be involved in, such as barrel maintenance, replacement of hydraulic seals, and mechanical adjustments. We also discussed some maintenance-related safety precautions. We concluded with a brief discussion of PMS, quality assurance, and safety.